Volume 68
Number 4

December, 1954
Pages 305-362

$4.00 a Year
$1.25 a Number

Journal of the New England Water Works Association

ISSUED QUARTERLY

Published by
NEW ENGLAND WATER WORKS ASSOCIATION
73 Tremont Street, Boston 8, Massachusetts

Entered as second-class matter September 23, 1903, at the Post Office of Boston, Mass., under the Act of Congress of March 3, 1879
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OF THE
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1954-1955

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THE Association was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of 900 men. Its membership is divided into six classes, viz.:

A Member shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

An Honorary Member shall be a person of acknowledged eminence in some branch of water supply or of engineering.

A Junior shall be not less than eighteen years nor more than twenty-five years of age, a student or connected with water supply work.

An Associate shall be either a person, firm or corporation engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works.

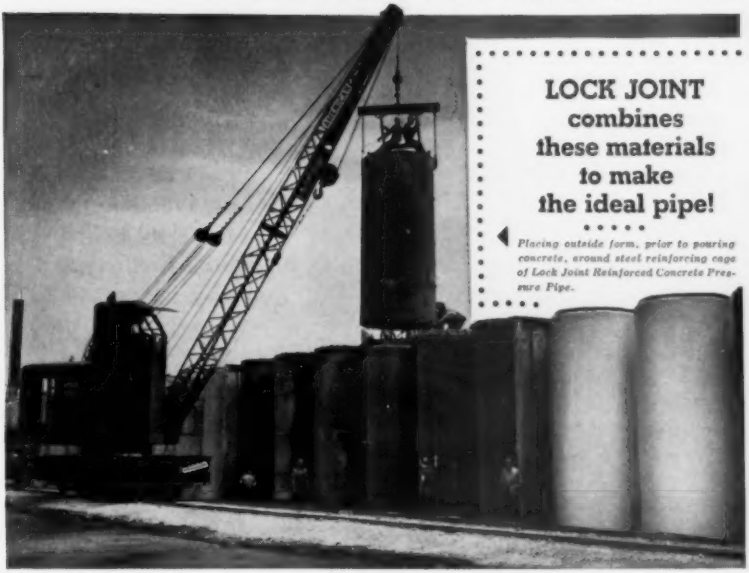
A Corporate Member shall be either a Water Board, Commission, Company or Municipal Corporation.

The initiation fees and annual dues are as follows:

	Initiation Fees	*Annual Dues*
Members	$ 5.00	$ 6.00
Juniors	1.00	3.00
Associates	10.00	20.00
Corporate Members	10.00	10.00

This Association has at least eight regular meetings each year, of which five are held in Boston, one in northern New England, one in southern New England, and one, the annual convention, held in September or October on such date as the Executive Committee may designate.

There's no substitute for CONCRETE and STEEL!



LOCK JOINT combines these materials to make the ideal pipe!

Placing outside form, prior to pouring concrete, around steel reinforcing cage of Lock Joint Reinforced Concrete Pressure Pipe.

CONCRETE, with its proven qualities of durability, non-corrosion, resistance to electrolytic action, and high compression strength is combined, by Lock Joint, with steel's toughness, resilience and high tensile strength to make a pipe that retains the best qualities of both—non tuberculance, high structural strength and long life with little or no maintenance. Dense concrete affords complete protection for the quality reinforcing steel. Both materials are carefully calculated to meet your pressure needs with a wide factor of safety. The Lock Joint Pipe Company's Rubber and Steel Joint is extremely watertight and, at the same time, flexible.

For superior strength, carrying characteristics and trouble-free operation, let Lock Joint supply your pipe needs in sizes 16" and larger.

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Established 1905

P. O. Box 269, East Orange, N. J.

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SEWER & CULVERT PIPE PLANTS:
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LOCK JOINT Reinforced Concrete PRESSURE PIPE

SCOPE OF SERVICES—*Lock Joint Pipe Company specializes in the manufacture and installation of Reinforced Concrete Pressure Pipe for Water Supply and Distribution Mains 16" in diameter or larger, as well as Concrete Pipes of all types for Sanitary Sewers, Storm Drains, Culverts and Subaqueous Lines.*

Joseph Morano, Water Commissioner, John A. Hastings, Superintendent and Gus Pledski, Meter Foreman with repaired meter that established outstanding service record.

Meter Sets Durability Record

Over 4½ million gallons measured by ⅝ inch Rockwell Arctic type over three year span.

Town of Clinton, Massachusetts
WATER DEPARTMENT
Office Board of Water Commissioners
359 HIGH STREET

Clinton, Mass.

April 6, 1954

Mr. Thomas F. Gallagher
Rockwell Manufacturing Company
708 Beacon Street
Boston 15, Massachusetts

Dear Tom:

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There's the story, Tom,---4½ mg measured for a parts cost of $2.40. What do you do with your old meters. . . shoot them?

Very truly yours,

John A. Hastings

John A. Hastings
Superintendent

Made Good As New With Only $2.40 Worth of Repair Parts

This meter ran continuously for over three years at breakneck speed. You couldn't put a meter to a more grueling test. Certainly, we don't recommend overspeeding meters. But this experience does demonstrate that Rockwell builds an extra measure of durability into water meters. That, plus long sustained accuracy and low maintenance costs are the *quality* factors you can be sure to get in every Rockwell meter you buy.

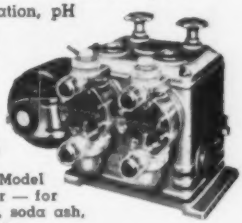
The Symbol for Service, Quality and Performance in Water Meters

ROCKWELL MANUFACTURING COMPANY

Pittsburgh 8, Pa. Atlanta Boston Charlotte Chicago Dallas Houston Los Angeles Midland, Texas N. Kansas City, Mo. New York Philadelphia, Pittsburgh San Francisco Seattle Shreveport Tulsa *Canadian Water Meter Sales: Peacock Brothers Limited*

May we help?

Solving water problems is our business. Our engineering files contain over 40,000 case histories cross-indexed for easy reference. Whatever your problem — whether it involves sterilization, coagulation, pH control, taste and odor control, or water filtration %Proportioneers% has the experience and equipment "in stock" to solve it.



%Proportioneers% Model 47 Chem-O-Feeder — for hypochlorite, alum, soda ash, lime, ferric sulphate.

%Proportioneers% world famous "Little Red Pump" — the Heavy Duty Midget Chlor-O-Feeder. Simple, adaptable, dependable. Recommended for a wide range of water treating applications.

May we help? Send for data and recommendations to Proportioneers, Inc., 366 Harris Ave., Providence 1, R. I.

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DIVISION OF B-I-F INDUSTRIES, INC.

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4—FLOODING.

The Smith Protectop Hydrant is designed to permit rapid return to service at minimum cost when a Hydrant is damaged as a result of a traffic accident.

The Protectop Hydrant Standpipe and Valve Stem are equipped with *Special Couplings* located just above the ground. The Couplings withstand operating pressures and ordinary impact with an ample factor of safety. Under excessive impact occasioned by traffic accidents the Couplings fracture at the design points thus minimizing the damage and permitting speedy return to service at low cost.

All Smith Hydrants are equipped with *Compression Type* Valves which definitely eliminate flooding since the line pressure holds the Valve against its seat in the closed position.

Write for details.

38

SMITH HYDRANTS SERVICE SINCE 1896

THE A.P. SMITH MFG. CO.

EAST ORANGE, NEW JERSEY

Thomas A. McEinstein admits his METER SHORT-FORM is a Flop!

No matter how cute a formula an inventive genius may develop to correct meter readings to what they would have been if the meter had been set in the position specified, he eventually comes to the conclusion that it doesn't pay to install a water meter sideways in a vertical water line. He should have used a Ford Copperhorn in the first place and kept his meter on the level . . . and it doesn't take a cost accountant or a time-study specialist to prove it. Write today for full information.

It's a cinch with a Copperhorn!

THE FORD METER BOX COMPANY, INC.

FOR BETTER WATER SERVICES

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NOW for the first time . . .

a complete well cleaning preparation

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for cleaning and developing water wells

WELTONE is our response to the demand for a complete well cleaning preparation containing Calgon.* WELTONE combines the well-known cleaning powers of Calgon with disinfecting and other chemicals which were frequently used with Calgon but purchased separately

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WELTONE is safe, will not harm metals or concrete, allowing cleaning with the pump in place Its exclusive dispersive action makes WELTONE highly efficient for developing new wells.

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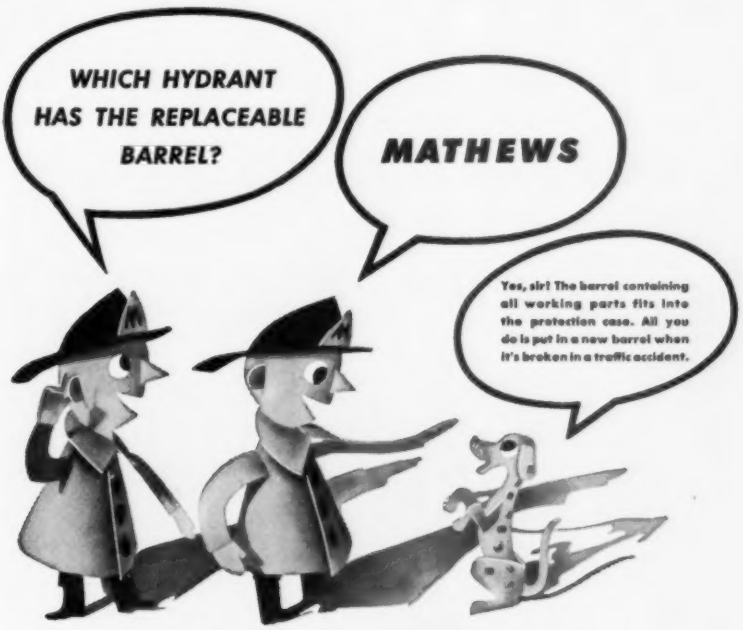
WHICH HYDRANT HAS THE REPLACEABLE BARREL?
MATHEWS
Yes, sir! The barrel containing all working parts fits into the protection case. All you do is put in a new barrel when it's broken in a traffic accident.

MATHEWS MEANS FIRE PROTECTION

LONG LIFE. Mathews Hydrants are protected at wear points by bronze bushings — corrosion and rust are licked.

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LOW-COST MAINTENANCE. Only one point requires lubrication — and that only during routine inspections.

REPLACEABILITY. A Mathews leveled in an accident can be replaced without excavating and in a jiffy. Community protection is interrupted only for minutes.

The Mathews includes every quality feature...

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MATHEWS HYDRANTS

Made by R. D. Wood Company

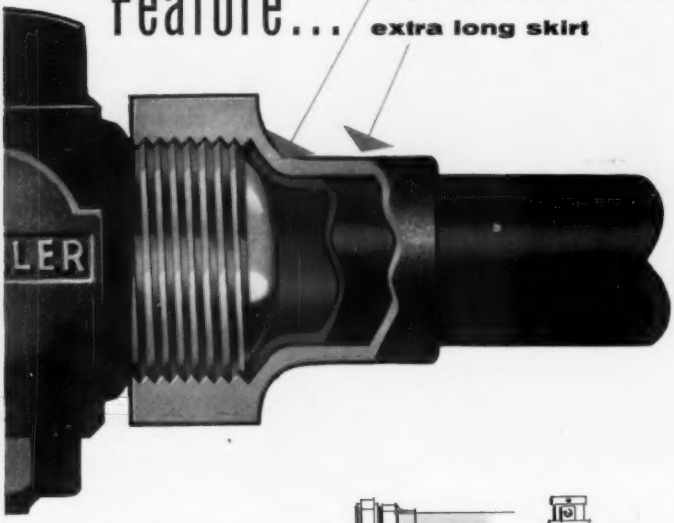
Public Ledger Building, Independence Square, Philadelphia 5, Pa.

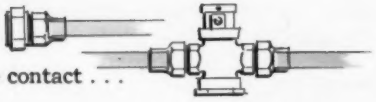
Manufacturers of "Sand-Spun" Pipe (centrifugally cast in sand molds) and R. D. Wood Gate Valves

MUELLER

COPPER CONNECTIONS

Feature . . . **opposed convex surfaces**
extra long skirt



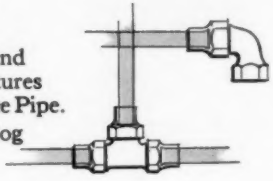


Opposed convex surfaces give line contact . . . a positive pressure seal!

Extra long skirt in tube nut gives the needed strength to the connection.

A full line of Corporation Stops, Curb Stops and Service Fittings with these and other plus features are available for use with Mueller Copper Service Pipe.

Consult your Mueller Representative or Catalog W-96 for full details.



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MUELLER CO.

Dependable Since 1857

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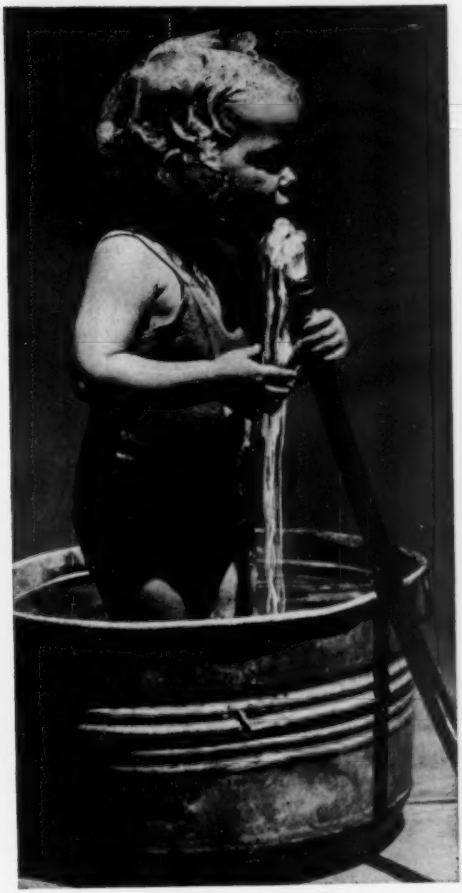

water is important to everybody...

The Miss at this fountain of youth would be mighty disappointed if low water pressure were suddenly to deprive her of a drink—and so would millions of others who take water pressure for granted. One of the best, and least expensive ways to assure the constant flow of water is through Centrilining.

The Centriline process thoroughly cleans and centrifugally applies cement-mortar to the interior of pipe lines in place—prevents corrosion, tuberculation and leakage; minimizes interruption of line operation and street traffic. For an effective, economical means of increasing flow capacity, look to Centriline.

Write for free booklet today.

CEMENT-MORTAR LININGS FOR PIPES IN PLACE

3,500,000 FEET OF EXPERIENCE

CENTRILINE CORPORATION

A subsidiary of Raymond Concrete Pile Co.

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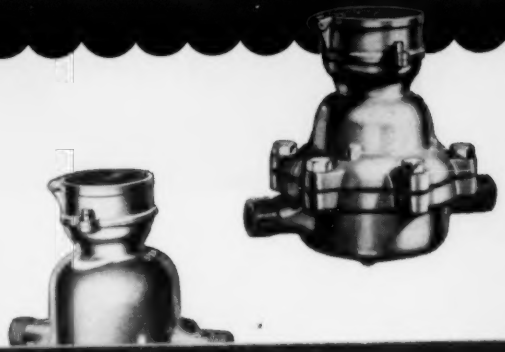
Branch Offices in Principal Cities of United States and Latin America

Water is vital...

BADGER *meters conserve it* **BETTER!**



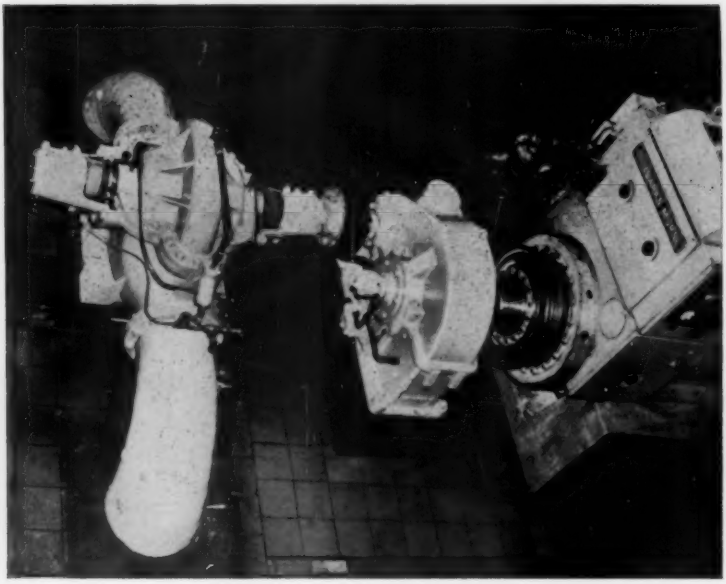
AMERICA'S steel production now tops 72,000,000 tons annually . . . yet it actually takes more water than iron ore to produce today's steel. Badger meters conserve water for such vital needs . . . measure water usage precisely . . . help eliminate water waste in thousands of communities. They make sure that homes and industrial projects alike receive a fair share of the supply, and pay a fair price for the water used. Thus, Badger meters actually help keep water departments self-supporting for thousands of communities. No wonder waterworks men everywhere praise Badger meters . . . recognize them as the meters that *save water, work and money — all ways.*

BADGER
Water Meters

Badger Meter Mfg. Co.
Milwaukee 45, Wisconsin

"Measures the water of the world"

ANOTHER FAIRBANKS-MORSE LEADER



12"x14" Fairbanks, Morse Figure 5814 Pumps

Pictured above is a bird's eye view of one of the two 12" x 14" Fairbanks, Morse Figure 5814 Double Suction Horizontal Split Case Centrifugal Pumps, supplying the Arlington, Arlington Heights and Belmont sections of the Metropolitan District Commission's Water Division.

Each of these two pumps rated at 6000 G.P.M. at 220 TDH is driven by an eight cylinder Model 31A8½ Fairbanks, Morse Diesel Engine.

Installed in early 1953 as part of the MDC's new expansion program, both pumps take suction from the Wachusett Reservoir, Clinton, Massachusetts, distributing main and boost the pressure in the area served.

A trained Fairbanks, Morse Engineer is on hand to help solve YOUR pumping problems.

Write or telephone to:

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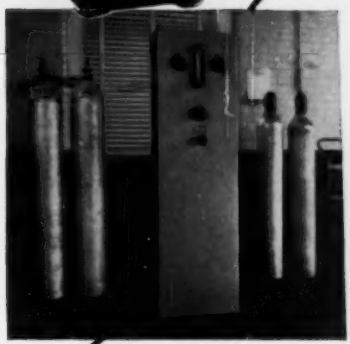
178 Atlantic Avenue **Boston 10, Massachusetts**

Telephone: LAfayette 3-3600

.....Call on the New England Sales Office of B-I-F Industries...



Builders Model DVS-M Chlorinizer at Pennichuck Water Works, Nashua, N. H.

PROPORTIONEERS
feeding and proportioning equipment for solutions . . . . . .

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OMEGA
volumetric and gravimetric feeders for dry and fluid materials . . . . . .

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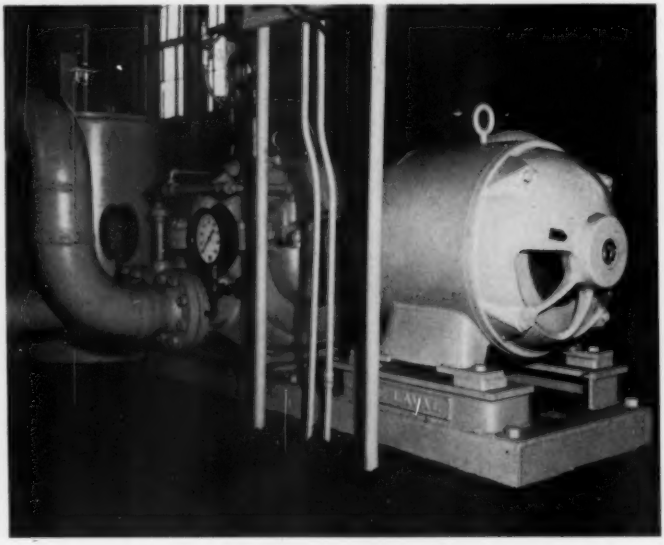

TOWN OF MEDWAY, MASSACHUSETTS

The above installation of a 2-stage De Laval pump with a 60 H.P. motor is typical of many of our New England water works plants.

The pump delivers 645 GPM against 277 ft. TDH with a suction lift of 17 feet.

Unlike the usual water works piping arrangement of cast iron pipe and fittings with bolted flanges it was necessary to use welded steel piping due to the cramped and limited space conditions of the existing piping.

TURBINE EQUIPMENT COMPANY OF NEW ENGLAND

80 Federal Street **Phone LIberty 2-5993** **Boston 10, Mass.**

New England Representatives for

DE LAVAL STEAM TURBINE COMPANY

TRENTON, NEW JERSEY

North Tank—500,000 gallon Double-Ellipsoidal unit. Tower height 39 ft.

Central Tank—500,000 gallon Double-Ellipsoidal design. Tower height 48 ft 4 ins.

BALANCED WATER STORAGE

AT DARTMOUTH, MASS.

PITTSBURGH •DES MOINES

Elevated Steel Tanks

The widely-spread community of Dartmouth, Massachusetts enjoys dependable water service at uniform pressures, thanks to three strategically-located P-DM Elevated Steel Tanks. The first tank, built in 1947, served the central area. Recent addition of the North and South units provides a completely balanced storage system. *Write for our Modern Water Storage Brochure.*

South Tank—300,000 gallon Double-Ellipsoidal design. Tower height 104 ft 3 ins.

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Plants at PITTSBURGH, DES MOINES and SANTA CLARA

Sales Offices at:

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NEWARK (2), . . 221 Industrial Office Bldg.	DALLAS (1), . . . 1229 Praetorian Building
CHICAGO (3), 1228 First National Bank Bldg.	SEATTLE . . . . . 532 Lane Street
LOS ANGELES (48), . . 6399 Wilshire Blvd.	SANTA CLARA, CAL. . . . 631 Alviso Road

Pipe Line Equipment
WATER · GAS · SEWER

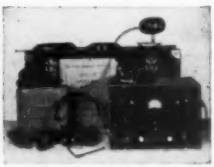
Bottled Gas Lead Melting Furnace

Asbestos Joint Runners

Best quality asbestos rope, brass caps attached to each end. Equipped with clamps.

M-D Cut-In Connections for Sewers

A light cast iron fitting with bell end for connecting house service with main sewer pipe without necessity for placing a Y-branch or T-branch in the sewer line.



Leak Detector

A truly fine instrument designed to solve even the most difficult leak detecting problem.

Calking Tool Outfit

For water mains up to 12". Strong leather bag. Keeps the right tool for every job within easy reach.

Test Plugs for Bell or Spigot End Cast Iron Pipe.

On this page are shown only a few of the hundreds of items to be found in the POLLARD Catalog. Write for a copy of Catalog No. 26F.

Portable Lead Melting Furnace

A handy outfit for quick action, equipped with gasoline burner.

Pipe Cutter

Inexpensive way of cutting pipe. Every wheel in contact with the pipe is a cutting disc, so cutter need be moved only a short distance to cut entirely around the pipe.

Tapax

The original manhole cushion. Takes the bang out of manhole covers.

New "Electronic Witch" M-Scope Pipe Finder

The first really NEW pipe Finder in 20 years.

JOSEPH G. POLLARD CO., INC.

Western Office
1064 Peoples Gas Bldg.
Chicago, Ill.

MAIN OFFICE AND FACTORY
New Hyde Park, N. Y.

Southern Office
333 Candler Bldg.
Atlanta, Ga.

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New England Water Works Association

ORGANIZED 1882

VOL. LXVIII DECEMBER, 1954 No. 4

This Association, as a body, is not responsible for the statements or opinions of any of its members

PROCEEDINGS

SEVENTY-THIRD ANNUAL CONVENTION

POLAND SPRING, ME.

OCTOBER 4-6, 1954

The Seventy-Third Annual Convention of the New England Water Works Association was held at the Poland Spring House, Poland Spring, Me., on October 4, 5 and 6, 1954.

MONDAY, OCTOBER 4

Morning Session

President William B. Duffy in the Chair.

The Annual Reports of the Secretary, Treasurer, and Finance Committee were presented and accepted, and those of the Editor, Committee on Technical Program, Committee on Membership, Committee on Committees, Committee on Legislation, and Committee on Reciprocal Relations with the Institution of Water Engineers were also presented.

The President declared the polls closed and appointed as tellers John H. Robinson, Willard S. Pratt and John J. Murphy.

The following reports of technical committees were presented: Committee on Coefficients for Friction in Pipe Lines, Committee on Specifications for Cast-Iron Pipe and Fittings, Committee on Reinforced-Concrete Pressure Pipe, Committee on Laying Cast-Iron Water Mains, Committee on Specifications for Steel Pipe, Committee on Standardization of Pipe Flanges and Fittings, Committee on Deep-Well Vertical Pumps, Committee on Water Rate Schedules, Committee on Conservation, Development and Utilization of Water Resources, Committee on Recreational Uses of Public Water Supplies, and Committee on Methods of Financing Water-Main Extensions. All the reports mentioned above are printed in this issue of the JOURNAL.

Upon recommendation of the Executive Committee, it was VOTED to accept the proposed revisions to the Specifications for Cast-Iron Pressure Fittings.

Secretary Knox announced the election by the Executive Committee of the following new members:

Anthony Richard Castorina, Chemist, Bridgeport Hydraulic Co., Bridgeport, Conn.; Blanche Adella Dobrzensky, Manager, The Newman Water Works Co., Newman, Cal.; Edward C. Hill, Superintendent, Water Company, Pembroke, Mass.; Louis Katona, Consulting Engineer, Norwood, Mass.; James Christian Lamb, III, Research Associate in Sanitary Engineering, Massachusetts Institute of Technology, Cambridge, Mass.; George Curtis Wallace, Project Engineer, Metcalf & Eddy, Boston, Mass.

Corporate Member

Fort Kent Water Co., Fort Kent, Me.

Associate Members

The Bond-O Company, Spring Valley, N. Y.; Millipore Filter Corp., Watertown, Mass.

Afternoon Session

A paper on "Reconstruction of Lebanon Reservoir, Using Precast Concrete Blocks for Riprapping" was read by Harry Manson, Superintendent, Water Works, Lebanon, N. H.

A paper on "Experience with Cleaning and Lining a 24-Inch Force Main" was read by Clarence L. Ahlgren, Assistant Superintendent, Water Works, Manchester, N. H.

A paper on "Submarine Troubles in Portland Harbor" was read by J. Porter Hennings, Superintendent, Portland Water District, Portland, Me.

Evening

An old-fashioned barn dance was held in the Playhouse. This event was sponsored by the Water and Sewage Works Manufacturers Association.

TUESDAY, OCTOBER 5

Morning Session

Papers on "Water Works Salaries" were read by Clifton E. Hodgdon, Superintendent, Lynnfield Center Water District, Lynnfield,

Mass., and Philip Welch, Commissioner of Public Works, Medford, Mass.

Then followed a panel discussion on "Electrical Equipment Maintenance." This was led by Leslie E. Clover, Plant Engineering and Maintenance Services, General Electric Co., Schenectady, N. Y., and included papers on "Motors and Their Maintenance," by Lewis T. Jester, Application Engineer, General Electric Co., Boston, Mass.; "Maintenance of Power Distribution Equipment," by Albert H. Ruling, Jr., Service Supervisor, New England District, General Electric Co., Boston, Mass.; and "Maintenance of Electrical Control," by Walter Hansen, New England District Control Specialist, General Electric Co., Boston, Mass.

Wednesday, October 6

Morning Session

A paper on "Radiation Experiences in Massachusetts Water Supplies" was read by Ralph M. Soule, Associate Sanitary Engineer, Massachusetts Department of Public Health, Boston, Mass.

A paper on "Water Purification in Cambridge, Mass." was read by David H. Turcotte, Chemist, Water Department, Cambridge.

A paper on "Determination of Charges for Public Fire Protection", prepared by Darrell A. Root and Thomas R. Camp, of Camp, Dresser & McKee, Boston, Mass., was read by Mr. Root.

Afternoon Session

A paper on "Water Supply and Treatment in 1984—Thirty Years of Progress" was read by Harry A. Faber, Managing Editor, Water & Sewage Works, New York, N. Y.

A paper on "Economics of Unit Water Purification Systems" was read by Charles A. Knapp, The Dorr Co., Inc., Stamford, Conn.

Evening

A social hour in the Patio, followed by a banquet in the dining-room of the Poland Spring House, was sponsored by the Water and Sewage Works Manufacturers Association.

AWARD OF THE DEXTER BRACKETT MEMORIAL MEDAL

PRESIDENT DUFFY. Next on the program I introduce to you Harold B. Scales, of the Portland Water District, who is Chairman of the Committee on the Award of the Dexter Brackett Memorial Medal and who will make a presentation of that award. Mr. Harold B. Scales.

HAROLD B. SCALES. Mr. President, members of the New England Water Works Association, and guests:

The Dexter Brackett Memorial Medal was established by the New England Water Works Association in 1916, to perpetuate the memory of a man who for many years contributed much to the waterworks profession. Early in his career Dexter Brackett was connected with the Boston Water Department and later with the Metropolitan Water System. With the latter organization he served as chief of the distribution system and later as chief engineer. He was president of our Association for the years 1889 and 1890, and for several years was Editor of our JOURNAL.

Your committee, consisting of Edwin M. Howard of Boston, Mass., Wayne F. Damon of Leominster, Mass., and Harold B. Scales of Portland, Me., were of the unanimous opinion that the most meritorious paper published in the JOURNAL in 1953 was "Some Aspects of the Water Supply to London," by Henry Francis Cronin, Chief Engineer of the Metropolitan Water Board, London, England.

Mr. Cronin, one of the outstanding engineers of Great Britain, was born in South Ireland, but spent most of his life in London. He attended the University of London, graduating with a degree of Bachelor of Science. He served in World War I, is an officer of the Order of the British Empire, a rank bestowed on worthy commoners by royalty, a past president of the Institution of Civil Engineers, a past president of the Institution of Water Engineers, and an honorary member of the New England Water Works Association. He has been with the Metropolitan Water Board for many years, serving first as deputy chief engineer and finally as chief engineer.

When officially notified that he was to be the recipient of the Dexter Brackett Memorial Medal, Mr. Cronin expressed his deep appreciation in a letter to the Association for the honor bestowed upon him and regretted that he could not be here to receive the medal in person. I, therefore, on behalf of the New England Water Works Association, present the Dexter Brackett Memorial Medal to Henry Francis Cronin *in absentia*. It will be forwarded to him in London at an early date.

COMMEMORATIVE AWARD

PRESIDENT DUFFY. We now come to the presentation of the Commemorative Award. This award, established in 1949, is in memory of members who have been prominent in the water-works field. Its purpose is to give due recognition to the paper judged next in merit to that of the Dexter Brackett Memorial Medal Award.

This year the award is made in memory of Robert C. P. Coggeshall. Mr. Coggeshall was Superintendent of the New Bedford Water Works and one of the group who organized this Association in 1882. He served as President, as Secretary, as a member of the Finance Committee, and also as Editor for many years. He was elected an Honorary Member in 1915. Mr. Coggeshall wrote seven papers for the JOURNAL of this Association, several on the subject of pumps and pumping stations.

Mr. Richard Hazen, Consulting Engineer of New York City, is the recipient of the Commemorative Award this year, for his paper entitled "Pumps and Pumping Stations."

If Mr. Hazen will step forward, it is my privilege now to present to him this set of books and a certificate of the Commemorative Award.

RICHARD HAZEN. I wish to thank the Committee for this award, and wish to thank them not only for myself but also for those of my associates who helped prepare the paper. I appreciate it very much.

* * * * *

PRESIDENT DUFFY. In accordance with our usual custom, it is my privilege and pleasure to present award certificates to those who have served the same municipality for 25 years, and who have been members of this Association for the same length of time.

Will those who are to receive the award please come forward when your names are called:

Elisha J. Dionne of Salem, Mass.; Joseph E. Moore of Bur-

lington, Vt.; Harry A. Nutting of Newmarket, N. H.; Earle A. Tarr of Winthrop, Me.; James V. Turner of East Providence, R. I.

These engraved certificates read as follows:

"THE NEW ENGLAND WATER WORKS ASSOCIATION

ORGANIZED 1882

This certifies that Elisha J. Dionne, for more than 25 years a member of the New England Water Works Association, was on this date, October 6, 1954, honored by the Association for having completed over a quarter of a century of efficient and faithful service in the Water Department of the City of Salem, Massachusetts, and is hereby commended for his loyal and capable public service."

[*The certificates are handed to Mr. Dionne and the others present.*]

Mr. Nutting's certificate will be mailed to him; he is not here.

At this time it is customary for the President to make a presidential address.

PRESIDENTIAL ADDRESS

By William B. Duffy

The Constitution of the New England Water Works Association directs the President to deliver an address at the Annual Convention. This, our 73rd Annual Convention, marks the first time the convention has been held entirely in the month of October.

The past year has gone along pleasantly and, I feel, successfully. A large measure of this is due to our able Secretary, Joseph C. Knox, and his assistant, Mrs. Alice Melrose. I am thankful to them for their fine work. I am grateful to the Executive Committee and the various other committees of the Association for their splendid assistance in running the affairs of the Association.

The Water and Sewage Works Manufacturers Association, through Herbert B. Crowell, Frank Wells and John Finn, has added a great deal by providing the exhibits and part of the entertainment.

The standing of this or any association can be measured by certain outstanding factors. One of these is the growth in membership. In 1917 the Association had 1,043 members. The number declined until 1943, when a slow but steady increase in membership occurred, until now we have 1,083 members. Much of the credit for this growth belongs to George Coffin and his energetic membership committee. During the past 15 years the figures for all grades of membership are as follows:

1940	801	1945	813	1950	921
1941	798	1946	826	1951	992
1942	808	1947	865	1952	1,042
1943	787	1948	898	1953	1,071
1944	800	1949	922	1954	1,083

The work of the Membership Committee should be encouraged and augmented. Junior members are provided for in the constitution and a drive for them in the engineering colleges would seem to be worth while.

Another index of the value of our Association is the attendance at the meetings. The following table gives the monthly attendance at the luncheons since 1939:

Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Total
1940-41	160	197	170	38	226	150	130	1,071
1941-42	163	166	205	155	173	141	110	1,113
1942-43	139	121	136	123	142	—	140	801
1943-44	135	108	145	184	160	—	145	877
1944-45	155	143	161	128	154	—	151	892
1945-46	143	87	116	147	166	123	153	935
1946-47	135	163	169	161	146	139	149	1,062
1947-48	123	136	122	129	157	181	141	982
1948-49	145	124	165	129	174	156	368	1,261
1949-50	115	150	153	142	167	126	122	975
1950-51	161	123	148	142	149	237	220	1,180
1951-52	131	176	161	184	165	165	147	1,129
1952-53	185	135	158	165	228	147	204	1,222
1953-54	156	148	180	189	199	160	230	1,262

This past year has seen the largest number in attendance in the history of the Association. This reflects the fine work of the Technical Program Committee, with Fred Smith as Chairman, Kenneth Knowlton in charge of the Chemists' Round Table, and Sherman Rogers in charge of the Superintendents' Round Table.

The policy of inviting some prospective junior members from our neighboring colleges to be guests at our monthly meetings is worthy of consideration by our Membership Committee, as an incentive to membership and to acquaint these young men with the field of water supply.

The financial affairs of the Association, ably handled by our Treasurer, William P. Melley, form another of the yardsticks by which to judge the standing of the Association. The expenditures are governed by the budget recommended by the Finance Committee, after being approved by the Association at the annual meeting. The following table shows the receipts, expenditures and invested funds since 1939:

Year	Receipts	Disbursements	Invested funds
1939	$12,458.54	$ 9,170.33	$16,379.71
1940	11,138.27	9,436.68	18,068.46
1941	10,568.01	9,917.04	18,068.46
1942	9,250.87	10,084.57	18,068.46
1943	8,940.24	10,359.04	18,068.46
1944	12,848.63	10,124.19	18,068.46
1945	10,267.59	9,446.21	18,068.46
1946	10,849.61	10,400.86	20,180.21
1947	11,958.28	11,742.79	20,563.46
1948	13,649.81	12,366.18	20,954.96
1949	13,948.76	14,250.12	21,348.96
1950	14,846.31	14,478.46	21,683.00
1951	14,275.46	15,109.74	20,097.50
1952	15,342.78	15,213.54	20,524.50
1953	15,060.39	16,494.51	20,964.50
1954	15,431.16	16,521.76	19,000.00

In only eight of the past 25 years have the expenditures exceeded the total receipts, while the invested funds have increased from $15,622.43 to $20,964.50 in that time. The so-called deficit budgets apparently are not affecting our financial position. The existence of such sizable invested funds over the years causes me to wonder if, for the sake of increasing our capital, we have not been too slow to expend funds for advancing the object for which this organization was founded in 1882. That object is the advancement of knowledge relating to water works and water supply and the advancement of professional and social intercourse among water-works men.

In view of our strong financial position and the desirability to further the object for which our organization exists, I am going to avail myself of this opportunity, as some of our other presidents have done, to recommend to the Finance Committee and the Executive Committee that the New England Water Works Association establish an undergraduate scholarship at the Massachusetts Institute of Technology for the son or daughter of any member of the New England Water Works Association who best meets the requirements of the Committee on Scholarships at the Massachusetts Institute of Technology and who will pursue a course of study directly connected with water works and water supply. The advantages to the Associa-

tion and to the water-works profession from this scholarship will be (1) to publicize the New England Water Works Association in every city and town in New England having a water system; (2) to encourage able students to enter the field of water supply; and (3) to increase the membership of the Association.

With assets of more than $22 per member at the present time, it does not seem unreasonable to spend fifty cents or even one dollar per member for the purposes of this scholarship. It represents to me a challenge to the organization to adopt a forward and progressive attitude toward the objects for which the New England Water Works Association was founded in 1882.

* * * * *

PRESIDENT DUFFY. The next item on the program is to call on John Robinson, the Chairman of the Tellers of Election.

REPORT OF THE TELLERS OF ELECTION

FOR PRESIDENT:	Roger G. Oakman	392—2 blanks
FOR VICE-PRESIDENT:	Edward L. Tracy	392—2 blanks
FOR DIRECTOR:	Clarence L. Ahlgren	390—4 blanks
FOR TREASURER:	William P. Melley	392—2 blanks

Total ballots cast, 394.

Respectfully submitted,

JOHN J. MURPHY
WILLARD S. PRATT
(*Signed*) JOHN H. ROBINSON, *Chairman.*

PRESIDENT DUFFY. Thank you, Mr. Robinson and the other members of the committee. By your report you have elected Roger G. Oakman of Needham, Mass., as President; Edward L. Tracy of Burlington, Vt., as Vice-President; Clarence L. Ahlgren of Manchester, N. H., as Director; and William P. Melley of Milton, Mass., as Treasurer.

In this, my final minute, let us say, of my term as President of the New England Water Works Association, I want the members to know that I shall appreciate always the honor and distinction of

having served you for the past year as President. It is a memory that I shall treasure and keep always as something that I feel has been well worth while. I have enjoyed it very much.

Now, as I turn the administration over to my successor, Roger G. Oakman, I wish him every success in his term of office as President of the New England Water Works Association. Roger Oakman. [*Applause.*]

PRESIDENT OAKMAN. Thank you, Past President William B. Duffy. It has been a pleasure to serve under you, and I am sure we are going to welcome you back into the fold of the Executive Committee of the New England Water Works Association for the next two years. I thank you.

Members, guests, friends of the New England Water Works Association: It certainly is a pleasure and an honor to be elected president of your Association, and I wish to thank each and every one for the confidence that he has shown in electing me to that office.

I am asking the members of the Association for their co-operation in assisting and giving data to the various committees, so that during the coming year we shall have meetings of interest to the Association. I am sure that we shall set up a program that will be of interest to all of us.

There are two or three announcements I wish to make at this time. After this meeting there will be dancing in the ball-room. And you might be interested in knowing that the next annual meeting of the Association will be held at Lake Placid, N. Y.

ANNUAL REPORT OF THE SECRETARY

August 31, 1954

Mr. President and Members of the New England Water Works Association:

The Secretary herewith submits the following report of the changes in the membership during the past fiscal year, and the general condition of the Association.

The present membership is 1,083, constituted as follows: 14 Honorary Members, 897 Members, 137 Associate Members and 35 Corporate Members.

Membership				Total
September 1, 1953—Honorary Members, Total				14
September 1, 1953—Members, Total		887		
Withdrawals:				
Died	15			
Dropped	6			
Resigned	21	42	845	
Elected:				
September 27, 1953	12			
October 16, 1953	4			
November 19, 1953	4			
December 17, 1953	4			
January 21, 1954	5			
February 18, 1954	4			
March 18, 1954	2			
April 15, 1954	1			
May 20, 1954	5			
June 17, 1954	7			
August 6, 1954	4		52	897

September 1, 1953—Associates, Total		134		
Withdrawals:				
Dropped	2			
Resigned	5	7	127	
Elected:				
November 19, 1953	1			
January 21, 1954	2			
March 18, 1954	2			
April 15, 1954	1			
May 20, 1954	2			
August 6, 1954	1		9	136
September 1, 1953—Corporates, Total		36		
Withdrawals:				
Dropped	1			
Resigned	1	2	34	
Elected:				
May 20, 1954	1		1	35
September 1, 1954—Total Membership				1,082
September 1, 1953—Total Membership				1,071
Gain of				11

Elections

Members

September 27, 1953—Arthur Ayotte, Russell D. Bartlett, Charles E. Cannon, Edward S. Holland, Charles G. Hammann, Clarence W. Metcalf, Addison P. Munroe, Richard G. Pike, Paige B. Rand, Homer R. Stickney, Robert T. Symonds and Thomas B. Williams, Jr. (12)

October 16, 1953—Albert H. Andrews, Richard F. Greeley, William E. Lyons and Clifford L. Williams. (4)

November 19, 1953—Sterling G. Brisbin, Martin E. Flentje, Stephen M. Hurley and Everett L. MacLeman. (4)

December 17, 1953—Ferd C. Arens, Charles G. Bourgin and Thomas P. Gallagher. (3) Reinstated: Hervey J. Skinner. (1)

January 21, 1954—Frederick L. Aldrich, Herbert P. Barton, John H. Duffy, Charles Nagy and Edward L. Tyler. (5)

February 18, 1954—John C. Clifford, Albert E. Feldman, Harry Larson and Herbert D. Nickerson. (4)

March 18, 1954—Clarence R. Day and Henry M. Paynter. (2)
April 15, 1954—Charles E. Cleveland. (1)
May 20, 1954—Wendell S. Brown, Henry H. Eastman, Clifton W. Ellis, Lardner H. Shull and E. Lincoln Swett. (5)
June 17, 1954—Douglas Dingwall, Frederick E. Griffin, James P. Kelley, Edward W. Leary, Harry P. Morrissey, Ernest F. Pike and James T. Putnam. (7)
August 6, 1954—Edward J. Hayden, George C. Kiefer, Jr., F. Alan Livingstone and Harold H. Marshall. (4)

Associate Members

November 19, 1953—Precision Chemical Pump Corporation. (1)
January 21, 1954—R. J. Berke & Company, Inc., and Mills Engineering Company. (2)
March 18, 1954—Fischer & Porter Company and Globe Rubber Works, Inc. (2)
April 15, 1954—Sparkler Manufacturing Company. (1)
May 20, 1954—Gil Moore & Company and Municipal Services. (2)
August 6, 1954—Sherman Products, Inc. (1)

Corporate Members

May 20, 1954—Brunswick-Topsham Water District. (1)

WITHDRAWALS

Members

Died—Harold K. Barrows, Arthur E. Blackmer, George N. Buckhout, Asa H. Copeland, Charles W. Harvey, Scotland G. Highland, Harry E. Holmes, Charles A. Maguire, Walter H. McMahon, Edward E. Minor, Fred B. Nelson, Roswell M. Roper, George E. Russell, Rossiter S. Scott and Walton H. Sears. (15)
Resigned—Harold J. Baker, Everett O. Boothby, Arthur L. Dopmeyer, Neil B. Faunce, John Gadd, Robert A. Glines, Arthur B. Graves, Jacob A. Handy, James J. Kehoe, Charles H. Lawrence, Paul W. Mack, Jack E. McKee, Frederick H. Miller, James I. Otis, Ralph M. Palmer, Earle L. Pike, Richard T. Ricker, Wilbur D. Smith, Wyman R. Stone, William L. Wenzel and John P. Wold. (21)
Dropped—Francis B. Crowley, William E. Duffy, Patrick J. Flynn, Madison H. Goff, Stewart H. Newland and Sidney A. Thompson. (6)

Associate Members

Resigned—Atlas Mineral Products Company, Lovell Chemical Company, National Supply Engine Corporation, Northrop and Company and the Preload Corporation. (5)
Dropped—Bowser, Incorporated, and Lead Industries Association. (2)

Corporate Members

Resigned—Newburyport Board of Water Commissioners. (1)
Dropped—Penacook-Boscawen Water Precinct. (1)

RECEIPTS FOR THE FISCAL YEAR SEPTEMBER 1, 1953, TO AUGUST 31, 1954

Entrance Fees	$ 233.00
Dues of Members of all grades	7,965.51
Dividends	564.50
Advertisements	5,892.02
Subscriptions	627.37
Journals	103.26
Membership certificates	45.50
	$15,431.16

There is due the Association:

Dues	$ 106.00
Advertising	48.75
	$ 154.75

Respectfully submitted,

(*Signed*) JOSEPH C. KNOX, *Secretary*

ANNUAL REPORT OF THE TREASURER

Boston, September 10, 1954

To William P. Melley, Treasurer,
New England Water Works Association,
Boston, Massachusetts.

We have examined the statement of assets and funds and the statement of cash receipts and disbursements of the general fund of the New England Water Works Association for the year ended August 31, 1954. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

We traced all recorded receipts into the depositary bank, verified the general fund bank account and petty cash fund as at August 31, 1954, and examined properly approved vouchers for all disbursements. On September 9, 1954, we examined the United States Treasury savings bonds and the paid-up cooperative bank shares at the First National Bank of Boston.

In our opinion, the accompanying statement of assets and funds and the note thereon and the related statement of cash receipts and disbursements of the general fund present fairly the financial position of the New England Water Works Association at August 31, 1954, and the recorded cash receipts and disbursements for the year then ended, on a cash basis consistent with that of the preceding year.

(*Signed*) SCOVELL, WELLINGTON & COMPANY

STATEMENT OF ASSETS AND FUNDS (Exhibit A)

As at August 31, 1954

Assets

Securities, invested funds		
U. S. Treasury savings bonds G 2½s, 1954	$10,000.00	
Braintree Co-operative Bank, 10 paid-up shares	2,000.00	
Milton Co-operative Bank, 15 paid-up shares	3,000.00	
Sandwich Co-operative Bank, 10 paid-up shares	2,000.00	
Stoneham Co-operative Bank, 10 paid-up shares	2,000.00	$19,000.00
General fund		
Cash, First National Bank of Boston	$ 4,802.59	
In office	50.00	
	$ 4,852.59	
Furniture and fixtures	1,180.00	6,032.59
		$25,032.59

Funds

Invested funds		$19,000.00
General fund		
Balance, August 31, 1953	$ 5,158.69	
Add Sale of Milton Co-operative Bank shares	2,000.00	
	$ 7,158.69	
Excess of disbursements over receipts, Exhibit B	(1,126.10)	
Balance, August 31, 1954		6,032.59
		$25,032.59

Note: The statement above, prepared on a cash basis, includes dues received in advance, $5,244.01, and employees' withholding tax, $136.60. It does not reflect the following:

Accounts receivable, dues	$ 106.00
Due on account of advertising	48.75
	$ 154.75

No depreciation has been taken on furniture and fixtures.

STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS (Exhibit B)

General Fund

For the year ended August 31, 1954

Receipts (exclusive of dues received in advance and employees' withholding tax)			
Initiation fees		$ 233.00	
Dues, 1953-1954 and prior years		2,721.50	
Interest		564.50	
From publication of Journal			
Advertisements	$5,892.02		
Subscriptions	627.37		
Sale of Journal	103.26	6,622.65	
Miscellaneous			
Membership certificates		45.50	
Total receipts			$10,187.15
Disbursements			
Publication of Journal			
Printing	$4,313.12		
Reprints	409.52		
Reporting	182.04		
Stationery and postage	353.01		
Editor's salary	750.00		
Sundry	101.07	$6,108.76	
General and administrative			
Certificates of membership	$ 25.91		
Secretary's salary	750.00		
Assistant to secretary—salary	3,120.00		
Treasurer's salary	200.00		
Printing, postage and stationery	218.79		
Office supplies and expense	233.79		
Office rent	1,260.00		
Electricity	85.06		
Telephone and telegraph	259.89		
Auditing	85.00		
Social security taxes	175.46		
Electric typewriter	343.92		
Fidelity bonds	93.75		
Sundry	54.91	6,906.48	
Forward		$13,015.24	$10,187.15

Meetings and committees			
Water works school	$ 100.00		
Printing, postage and stationery	1,467.96		
Convention expense	313.11		
Dinners	979.76		
Contribution to June conference	150.00		
Publicity	250.00		
Sundry	243.17	3,504.00	
Interest added to co-operative bank shares		35.50	
Total disbursements			16,554.74
Excess of disbursements over receipts (exclusive of dues received in advance and employees' withholding tax for current year)			($6,367.59)
Dues received in advance		$5,244.01	
Employees' withholding tax			
Payment for prior year	$139.12		
Less Receipts for current year	136.60	(2.52)	5,241.49
Excess of disbursements over receipts, Exhibit A			($1,126.10)
Balance, general cash, August 31, 1953		$3,978.69	
Add Sale of Milton Co-operative Bank shares		2,000.00	5,978.69
Balance, general cash, August 31, 1954			
Represented by			
Cash in First National Bank of Boston		$4,802.59	
Cash in office		50.00	
			$4,852.59

ANNUAL REPORT OF THE EDITOR

To the New England Water Works Association:

The Editor submits herewith his report for the year ending August 31, 1954. The financial figures, tabulated in the report, are derived from the report of the Treasurer, which contains a detailed statement of the receipts and disbursements on account of the September and December, 1953, and March and June, 1954, issues of the JOURNAL.

In Table 1 is presented a statement of the material contained in the four issues of the JOURNAL for the past year, while in Table 2 is given a comparison of the JOURNAL for the past year with those for preceding years.

TABLE 1.—STATEMENT OF MATERIAL IN SEPTEMBER AND DECEMBER, 1953, AND MARCH AND JUNE, 1954, ISSUES OF THE JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION

	Papers	Proceedings*	Total text	Index	Advertisements	Cover and contents	Insert plates	Total pages	Total cuts
Sept., 1953	61	59	120	0	45	4	1	170	29
Dec., 1953	42	67	109	6	48	4	0	167	6
Mar., 1954	38	57	95	0	49	4	1	149	17
June, 1954	91	21	112	0	49	4	1	166	15
Total	232	204	436	6	191	16	3	652	67

*Including standard specifications and recommended practice.

Size. The four issues contained 652 pages, of which 436 were text.

Cost. The gross cost of the JOURNAL was 6,108.76, equivalent to $5.68 per member; the surplus was $513.89, equivalent to $.48 per member.

Reprints. Reprints of papers have been furnished to authors at cost.

TABLE 2.—COMPARISON OF JOURNALS OF THE NEW ENGLAND WATER WORKS ASSOCIATION
Four Issues for Fiscal Year Ending August 31

	1945	1946	1947	1948[1]	1949[2]	1950[3]	1951[4]	1952[5]	1953[6]	1954[7]
Average edition (copies printed	1,200	1,200	1,275	1,350	1,325	1,250	1,300	1,390	1,420	1,442
Average membership	806	820	846	876	905	921	957	1,017	1,057	1,077
Circulation at end of year	1,032	1,042	1,083	1,129	1,164	1,172	1,240	1,283	1,331	1,334
Pages of text	438	391	428	411	452	440	423	463	421	436
Pages of text per 1,000 members	543	477	516	469	500	477	442	456	398	405
Total pages, all kinds	630	586	632	615	661	666	703	671	635	652
Total pages per 1,000 members	782	715	747	702	731	723	734	660	601	606
GROSS COST:										
Total	$3,734.19	$4,053.08	$4,193.60	$4,239.64	$5,016.44	$5,240.51	$6,069.62	$5,423.98	$5,865.67	$6,108.76
Per copy	0.78	0.84	0.82	0.78	0.95	1.05	1.17	0.98	1.03	1.06
Per page	5.83	6.91	6.63	6.90	7.60	7.86	8.64	8.08	9.23	9.37
Per member	4.63	4.94	4.96	4.84	5.55	5.69	6.34	5.34	5.55	5.68
Per member per 1,000 pages	7.35	8.43	7.85	7.87	8.40	8.55	9.02	7.96	8.75	8.71
Per member per 1,000 pages of text	10.57	12.62	11.58	11.78	12.28	12.92	14.99	11.52	13.19	13.03
SURPLUS:										
Total	$455.57	$162.33	$913.91	$1,990.81	$1,058.96	$1,294.73	$351.34	$1,040.76	$500.97	$513.89
Per copy	0.09	0.03	0.18	0.37	0.20	0.26	0.07	0.19	0.09	0.09
Per page	0.72	0.28	1.44	3.32	1.60	1.94	0.50	1.55	0.79	0.79
Per member	0.57	0.20	1.08	2.28	1.17	1.41	0.37	1.02	0.47	0.48
Per member per 1,000 pages	0.90	0.34	1.71	3.71	1.77	2.12	0.53	1.52	0.74	0.73
Per member per 1,000 pages of text	1.29	0.51	2.52	5.55	2.59	3.20	0.88	2.20	1.12	1.10

1Including 54 pages of standard specifications.
2Including 107 pages of standard specifications and recommended practice.
3Including 25 pages of standard specifications.
4Including comprehensive index, 1882 to 1950.
5Including 16 pages of standard specifications.
6Including 87 pages of standard specifications and recommended practice.
7Including 71 pages of standard specifications and recommended practice.

Circulation. The present circulation of the JOURNAL is:

Members, all grades	1,082
Subscribers	164
Exchanges	22
Advertisers	66
Total	1,334

JOURNALS have been sent to all subscribers and to advertisers.

Respectfully submitted,

(*Signed*) GEORGE C. HOUSER, *Editor*

ANNUAL REPORT OF THE FINANCE COMMITTEE

August 31, 1954

To the Executive Committee of
the New England Water Works Association:

The Finance Committee herewith submits its report on the budget for the year 1953-1954, and its recommended budget for the year 1954-1955.

The Committee has examined the figures obtained from the records of the Association during the past year, and has consulted with the Treasurer with reference to probable revenue and disbursements during the coming year.

The following changes have taken place in the membership:

	Resigned	Died	Dropped	Elected	Loss	Gain
Members	21	15	6	52		10
Corporates	1		1	1	1	
Associates	5		2	9		2
	27	15	9	62	1	12

The following tabulation is the estimated and actual budget for the past year:

REVENUE FOR 1953-1954

	Budget	Actual
Initiation Fees	$ 200.00	$ 233.00
Dues	7,600.00	7,965.51
Interest	350.00	564.50
Advertising	6,300.00	5,892.02
Journal receipts		730.63
Miscellaneous	50.00	45.50
	$14,500.00	$15,431.16

DISBURSEMENTS FOR 1953-1954

	Budget	Actual
General and Administrative	$ 7,000.00	$ 6,909.00
Journal	6,000.00	6,108.76
Meetings and Committees	3,000.00	2,418.17
Net expense of luncheons	800.00	835.83
Contingencies	400.00	
Publicity	400.00	250.00
	$17,600.00	$16,521.76

The estimated deficit for the past year was $3,100, while the actual deficit amounted to $1,090.60. Once again, the difference between the estimated and the actual deficit was due to the promptness with which the members paid their dues. The actual revenue exceeded the estimated by $931.16, due to many contributing factors, chief among which being the continued increase in membership, the sale of JOURNALS and advertising.

The disbursements were within the confines of the budget, with the exception of the items covering the JOURNAL and luncheons. These amounts were only slightly over the amounts set forth in the budget.

Inasmuch as the Executive Committee has established the policy of printing the membership lists every five years, and the year for printing will be 1955, we have provided funds for that purpose.

The Finance Committee has again set up a deficit budget for the coming year.

BUDGET FOR 1954-1955—REVENUE

Initiation Fees	$ 200.00
Dues	7,900.00
Interest and dividends	450.00
Journal advertising	5,700.00
Other Journal receipts	600.00
Miscellaneous	50.00
	$14,900.00

BUDGET FOR 1954-1955—DISBURSEMENTS

General and Administrative	$ 7,400.00
Journal	6,200.00
Meetings and Committees	3,000.00
Net expense of luncheons	900.00
Membership lists	750.00
Contingencies	500.00
	$18,750.00

We refer you to the Treasurer's report for further financial details, and to the Secretary's report for changes in the membership listing.

Respectfully submitted,

(*Signed*) HAROLD J. TOOLE, *Chairman*
THOMAS S. LAWRENCE
GEORGE N. WATSON

REPORT OF COMMITTEE ON TECHNICAL PROGRAM

August 31, 1954

To the New England Water Works Association:

The report of the Technical Program Committee is herewith presented.

Technical programs were arranged for the five Boston meetings, the June Outing and the Annual Convention.

Mr. Sherman L. Rogers and Mr. Kenneth F. Knowlton arranged interesting programs for the Superintendents' and Chemists' meetings.

The Chairman expresses his appreciation to the members of the Technical Program Committee, the Officers of the Association, and the Secretary's office for their cooperation during the year 1953-54.

(*Signed*) F. E. SMITH, *Chairman*

REPORT OF MEMBERSHIP COMMITTEE

October 1, 1954

To the New England Water Works Association:

During the past year sixty-three (63) have been elected to membership in the Association with nine (9) applications pending. On the assumption that these nine applications are acted upon at the October meeting favorably, the membership will stand at 1,092.

Unfortunately, we have lost 51 memberships through death and resignations, so that the net gain in membership is only 20.

This emphasizes the need of continuing our activities for new members. We feel that the invitation form which we have used the past three years has been quite effective and recommend its use again next year, together with a simple form of follow-up letter to those who have been previously invited to join the Association.

The several members of the Committee have been most cooperative in furnishing lists of prospective members and their assistance is appreciated by the Chairman.

Respectfully submitted,

(*Signed*) GEORGE W. COFFIN, *Chairman*
JOHN J. BAFFA
G. ARTHUR FANEUF
HOWARD H. POTTER
FRED P. STRADLING
RICHARD S. WOODHULL

REPORT OF THE COMMITTEE ON COMMITTEES
1953-1954

To the New England Water Works Association:

During the past year the Committee on Committees was again composed of the members of the Executive Committee, in order that the officers of the Association might keep in close contact with the activities of the various technical committees.

The function of the Committee on Committees is to coordinate the work and review the progress of the technical committees of the Association. It makes recommendations for the continuance of active committees and the discharge of those whose duties have been fulfilled, and proposes the establishment of new committees.

Establishment of New Committees

The following new committees were established during the year:

N.E.W.W.A. 46—Committee on Plastic Pipes and Plastic Linings for Water-Supply Uses
47—Committee on Methods of Financing Water-Main Extensions
48—Committee on Standard Specifications for Asbestos-Cement Water Pipe

In addition to these technical committees, the Executive Committee established a Committee on Salaries of Water Works Superintendents and Engineers. This committee will submit to the Executive Committee the results of its study, together with recommendations for action which the Association may take in this matter.

Continuation or Discharge of Committees

The Committee on Committees recommends that the committees listed be continued or discharged as indicated:

Committees to Be Continued

N.E.W.W.A. 8—Committee on Legislation
9—Committee on Reciprocal Relations with the Institution of Water Engineers (England)

11—Committee on Survey of Ground Water Supplies in New England
12—Committee on Rainfall and Yield of Drainage Areas
16—Committee on Coefficients for Friction in Pipe Lines
19—Committee on Water Quality and Treatment
20—Committee to Report on Developments in Our Knowledge of Corrosion and its Mitigations
21—Committee on Specifications for Cast-Iron Pipe
22—Committee on Reinforced-Concrete Pressure Pipe
23—Committee on Code for Pressure Piping
24—Committee on Laying Cast-Iron Pipe
25—Committee on Specifications for Steel Pipe
26—Committee on Standardization of Pipe Flanges and Fittings
28—Committee on Steel Standpipes and Elevated Tanks
30—Committee on Meter Specifications
32—Committee on Gate Valves
37—Committee on Federal Activities
38—Committee on Fluid Permeability
39—Committee on Deep-Well Vertical Pumps
41—Committee on Interstate Aid in Civil Defense
42—Committee on Conservation, Development and Utilization of Water Resources
44—Committee on Publicity
45—Committee on Recreational Uses of Public Water Supplies
46—Committee on Plastic Pipes and Plastic Linings for Water-Supply Uses
47—Committee on Methods of Financing Water-Main Extensions

Committees to Be Discharged

N.E.W.W.A. 40—Committee on Water-Rate Schedules
48—Committee on Standard Specifications for Asbestos-Cement Water Pipe

Conclusions

The work of the technical committees is of vital importance to the membership of the Association in the advancement of knowledge relating to water works.

The Committee on Committees appreciates the time and effort being given by the technical committees in carrying out their assignments, and desires to assist them in every way possible. In this connection the committee welcomes all suggestions for the establishment of new committees on subjects which will be beneficial to the waterworks profession.

Respectfully submitted,

COMMITTEE ON COMMITTEES

ANNUAL REPORT OF THE COMMITTEE ON LEGISLATION

October 4, 1954

To the New England Water Works Association:

Your Legislative Committee submits herewith its report on activities in the legislatures of the New England states during the year 1954.

Sessions were held in only two states—i.e., Massachusetts and Rhode Island.

Although the Connecticut General Assembly did not meet, an interesting development did occur relative to the Act passed by the 1953 General Assembly, which authorized reimbursement to utilities for expenses incurred in changing underground structures necessitated by non-access (throughway) state highway construction projects.

The law provided that the cost of such changes should be "equitably shared" by the state and the utility. The state highway commissioner originally interpreted the Act to mean that the Highway Department would reimburse the utility for practically the entire cost of necessary changes, less depreciation and salvage value of materials recovered.

Subsequently the Attorney General ruled that "equitable sharing" meant "equal sharing". This interpretation resulted in considerable dissatisfaction among the various utility companies of the state, and the Attorney General was finally prevailed upon to reconsider his opinion, with the result that the sharing of costs is now left largely to the judgment of the state highway commissioner, with provision for appeal to the Superior Court.

Your committee member covering developments at the 1954 session of the Rhode Island General Assembly reports that no legislation having a relation to water works or water-supply activities was enacted.

Proceedings during the session of the Massachusetts General Court deemed worthy of reporting to this Association are as follows:

All proposed legislation, relating to the fluoridation of public water supplies, after numerous lengthy hearings and debate, failed of passage and was referred to the next annual session.

Likewise, Senate 463 was so rejected. This measure would have required the Massachusetts Department of Health, in situations where a city or town holds land in another city or town for water-supply protection purposes, upon petition of the selectmen or taxpayers of the latter, to schedule a hearing and determine if such holding of land continued necessary. If the department rendered a negative decision, then public sale of the land within 30 days would have been mandatory.

House 2808, based on Senate 418, a bill to authorize the levy of special assessments to meet the cost of laying water pipes in public ways, again failed of passage. Annually, over the past several years, this proposed permissive legislation has received uniformly favorable committee reports, but for some undetermined reason falls short of enactment into law.

The following measures were passed into law:

Chapter 487, ENTITLED "AN ACT RELATIVE TO LIENS FOR WATER RATES AND CHARGES". This is an amendment of sections 42A to 42F, inclusive, of chapter 40 of the general laws and shall take effect on January 1st, 1955. The provisions of the amended sections shall continue to apply without further acceptance to all cities, towns, water districts and fire districts supplying water to which said sections applied immediately prior to the above effective date. The subject sections, as in effect immediately *prior* to the effective date of this act shall apply on any water rates and charges which carried a due date *prior* to January 1st, 1955. Acceptance of the provisions of the "lien law" is still permissive, as formerly, and in conformity with established procedure. On the basis of the amended law, section 42B provides that "Such lien shall take effect *by operation of law* on the day immediately following the due date of such rate or charge". Section 42C outlines the procedure under which such lien is committed by the local board of assessors with their warrant to the collector of taxes as a part of the real-estate tax. Not to be lost sight of is the elimination of former costs of filing and releasing water liens at the registry of deeds and the clerical work attached thereto.

Chapter 610—"AN ACT RELATIVE TO THE FILING OF SCHEDULES OF WATER RATES, PRICES AND CHARGES OF WATER DISTRICTS WITH THE DEPARTMENT OF PUBLIC UTILITIES." This amendment of chapter 165 of the general laws requires that water districts shall file with the Public Utilities Department schedules, in such form as said department shall from time to time prescribe, showing all rates, prices and charges to be charged or collected within the commonwealth for the sale and distribution of water.

Your committee wishes to point out that the Public Utilities Department has no control over the rates and charges of water districts, regardless of the mandatory filing.

Senate 650—"REPORT OF THE SPECIAL COMMISSION ESTABLISHED TO INVESTIGATE AND STUDY RELATIVE TO THE ADVISABILITY AND FEASIBILITY OF ESTABLISHING A SOUTHEASTERN MASSACHUSETTS WATER DISTRICT." After the filing of the report December 2, 1953, and subsequent to further study and hearing, the General Court adopted the following resolves:

Chapter 54—RESOLVE PROVIDING FOR A STUDY RELATIVE TO THE EXTENSION OF THE METROPOLITAN WATER SYSTEM MAINS INTO THE COUNTIES OF PLYMOUTH AND BRISTOL. The findings and recommendations of the Metropolitan District Commission, authorized to make a comprehensive investigation, together with an estimate of costs and draft of proposed legislation, if any, shall be filed with the clerk of the Senate on or before the last Wednesday of December in the current year.

Chapter 55—RESOLVE PROVIDING FOR AN INVESTIGATION AND STUDY BY A SPECIAL UNPAID COMMISSION OF GROUND WATER SUPPLIES AND OF DETERMINING NEW SOURCES THEREOF, IN THE COUNTIES OF PLYMOUTH AND BRISTOL. The Director of the Division of Sanitary Engineering in the Department of Public Health and two water-supply men, appointed by the Governor, form a three-man commission to investigate and report to the General Court on this whole subject, in like manner and on or before the same date as required in Chapter 54 above.

Chapter 67—RESOLVE PROVIDING FOR AN INVESTIGATION AND STUDY BY THE DEPARTMENT OF PUBLIC HEALTH RELATIVE TO THE PRESERVATION OF THE PURITY OF CERTAIN WATER SUPPLIES. The provisions of this Resolve are a development based on the situation in Southeastern Massachusetts, which resulted in the filing of Senate 463, previously mentioned in this report. This resolve requires an intensive study of present law and regulation, with a view to revision if feasible, as related to the general subject of protection of the purity of certain municipal water supplies, as said purity may be affected by public swimming, bathing, boating, fishing and other recreational use. In addition, the subjects of taking and holding land for municipal water-supply protection, the cultivation of cranberry bogs with inherent plant disease and insect control, as related to municipal water-supply considerations, are due for thorough exploration. Due date for the department report to the General Court—on or before the first Wednesday of December, 1956.

Chapter 71—RESOLVE REVIVING AND CONTINUING THE SPECIAL COMMISSION ESTABLISHED TO INVESTIGATE AND STUDY THE FEASIBILITY OF ESTABLISHING A SOUTHEASTERN MASSACHUSETTS WATER DISTRICT. Under the provisions of

this chapter the special commission continues the study of all factors related to the establishment of the subject water district in Plymouth and Bristol counties, with a full report to be filed with the clerk of the Senate on or before the first Wednesday in January, 1956.

In conclusion, of interest to our members who are included in the member communities of the Metropolitan Water District is passage of Chapter 278—AN ACT AUTHORIZING THE METROPOLITAN DISTRICT COMMISSION TO ERECT A NEW STANDPIPE IN THE WEST ROXBURY DISTRICT OF THE CITY OF BOSTON AND TO CONSTRUCT A WATER MAIN TO THE TOWN OF NORWOOD. This authorized construction and further provisions of this act provide, among other things, the means by which the town of Norwood will come into the water district as a member.

Respectfully submitted,

(*Signed*) MARK F. CROKER, *Chairman*
WARREN A. GENTNER
WILLIAM A. HEALY
PHILIP J. HOLTON, JR.
PETER C. KARALEKAS
EDWIN T. McDOWELL
EDWARD L. TRACY

REPORT OF THE COMMITTEE ON RECIPROCAL RELATIONS WITH THE INSTITUTION OF WATER ENGINEERS (LONDON)

October 4, 1954

To the New England Water Works Association:

The Committee on Reciprocal Relations with the Institution of Water Engineers of Great Britain presents herewith its report for the past year:

Under the reciprocal arrangement, the Institution has submitted to your Committee four papers published in the Journal of the Institution during the years 1949-1952, inclusive, one of which papers is to be selected as worthy of the Diploma presented by the Association at intervals of four years to the member of the Institution preparing the paper.

The four papers submitted by the Institution were published respectively in its Journal in each of the aforementioned years. These papers are listed as follows:

"The Vyrnwy Aqueduct: Fourth Instalment Pipeline" by W. F. White, Water Engineer, Torquay.

"The Relining of Water Mains in situ" by Alan Atkinson, Waterworks Department, Manchester.

"The Haweswater Reservoir" by G. E. Taylor, Water Engineer's Office, Manchester.

"The Covering of Two Service Reservoirs with Barrel Vault Roofs" by C. A. Serpell, Sunderland and South Shields Water Company, Sunderland.

All four papers are of outstanding merit and your Committee found it somewhat difficult to decide between the paper by Mr. Taylor and that by Mr. Atkinson. However, the Committee felt that the paper by Mr. Atkinson would be of value to practically all members of the Association, whereas that by Mr. Taylor would be of value to the limited number of members who are called upon from time to

time to design dams. Consequently, your Committee has selected Mr. Atkinson's paper as the most worthy of the Association's Diploma.

It is the intention of the Chairman of your Committee to attend the summer meeting of the Institution next May and he will plan to present the Diploma to Mr. Atkinson at that time.

Respectfully submitted,

(*Signed*) E. Sherman Chase, *Chairman*
Leland G. Carleton
Percy A. Shaw

REPORT OF COMMITTEE ON COEFFICIENTS FOR FRICTION IN PIPE LINES

September 24, 1954

To the New England Water Works Association:

In 1933 the New England Water Works Association authorized the formation of a Committee on "Pipe Line Friction Coefficients". This Committee in 1935 presented a most carefully prepared, informative and noteworthy report, based on 473 tests in 19 different water-works systems. The scope of the committee work included a study of the age-relationship and the effect of velocity and of various chemical ingredients in the waters on the rate of loss of carrying capacity in tar-coated cast-iron pipe.

In brief, the conclusions of this 1935 Committee Report indicated that

1) The actual loss in carrying capacity of tar-coated pipe, after 30 years' service, exceeded the loss predicted in the Williams-Hazen tables for "Average Soft Unfiltered River Water".
2) The Williams-Hazen coefficient relationship is applicable primarily to large-diameter mains, carrying relatively inactive waters.
3) The chemical composition of the water is an important factor in the reduction of pipe carrying capacity and a correlation exists between the pH value of water carried and the rate of capacity loss.

Numerous other articles setting forth factual data on age-coefficient relationship in steel and cast-iron pipe and corrective measures to reduce the rate of loss are available in water-works and general engineering literature.

While the 1935 Committee Report pointed out that it was not improbable that water treatment incident to filtration might increase the rate of reduction in carrying capacity and while this has been

known to have resulted in isolated cases, this trend has recently come forcibly to the attention of water-works profession in connection with the adoption of filtration and treatment in plants using Great Lakes waters. In Chicago and other Great Lakes cities there are instances of record where, within a period of 5 years after the introduction of filtration, there has been an average of 25% decrease in the carrying capacity of existing water mains. While studies have not progressed to the degree where conclusions are warranted, it is believed that such factors as (1) high chlorine residuals (free chlorine), (2) high pH in plant effluent, and (3) excessively high filtration rates, individually or in combination with each other and/or with other factors, may be directly or indirectly responsible for the decrease in the carrying capacity of the mains.

As a result of these recent incidents of accelerated rate of loss of carrying capacity subsequent to the introduction of filtration, a research project has been undertaken—at the instigation of the American Water Works Association—to determine the effect of different materials, used in filtration and treatment processes, upon the carrying capacity of distribution piping. This project is being financed through the National Health Institute by a grant of $20,000 for one year's work. It is expected that similar grants will again be made available for at least two subsequent years.

Work under this grant is being conducted under the direction of Dr. A. M. Buswell at the University of Illinois. The initial work will cover Great Lakes waters exclusively, in order to provide a common denominator in the basic characteristics of the water, modified only to the extent that water-treatment procedures vary in one or another community.

As a first step in this project, field studies of distribution-system conditions in cities using treated water from the Great Lakes and down the St. Lawrence as far as Montreal have been conducted. Results of these studies are expected to be made available shortly and will be used as a base for the detailed investigation to determine the effects of the various different materials used in filtration and treatment on the carrying capacity of cast-iron mains.

Two other independent research studies, one under the direction of Martin E. Flentje, Research Engineer, American Water Works

Service Company, and the other by Gregg Company, Inc., Philadelphia, are now being conducted to determine ways and means of minimizing the loss in carrying capacity of cement pipe and cement-lined pipe, subjected to waters of various compositions.

While the work now in progress at the University of Illinois is confined principally to the effect of treatment of Great Lakes waters, it is expected that the result of this work may well lead to the determination of the elements in a water, other than those involved in filtration, which are responsible for the loss of carrying capacity in cast-iron pipes. In view of the broad scope of this research project, as well as expected results from the other two independent projects, it would seem advisable, at this time, to confine the work of the present Committee on Coefficients for Friction in Pipe Lines to reporting to the Association the results obtained by others working in this field. Without the expenditure of considerable money and the employment of engineers who can devote themselves exclusively to such a study, it would appear that efforts on the part of the New England Water Works Association Committee could not produce results such as may be expected from the research work being done under the direction of Dr. Buswell.

Respectfully submitted,

(*Signed*) RICHARD H. ELLIS, *Chairman*
E. SHAW COLE
F. W. HALEY
BYRON MCCOY
WM. E. STANLEY

REPORT OF COMMITTEE ON SPECIFICATIONS FOR CAST-IRON PIPE AND FITTINGS

September 15, 1954

To the New England Water Works Association:

Your representatives on Committee A21 of the American Standards Association have continued in readiness to deal with matters relating to the work of this Committee. There has, however, been little to do because of the approaching completion of work on the various specifications relating to cast-iron pipe. When the last of these have been published in the tentative or final form, it is presumed that the committee will be discharged. Until that time, it would be appropriate to continue the NEWWA representation on the Committee.

Yours respectfully.

(*Signed*) RICHARD HAZEN
ARTHUR L. SHAW

REPORT OF COMMITTEE ON REINFORCED CONCRETE PRESSURE PIPE

To the New England Water Works Association:

Work of this committee has consisted of the consideration of minor suggested revisions in the specifications for all types of reinforced-concrete pipe, and of the attention to, and study and investigation of, certain reports concerning the alleged failure of prestressed reinforced-concrete pipe to give service over a proper extended period of time.

(*Signed*) STANLEY M. DORE, *Chairman*

PROGRESS REPORT OF COMMITTEE ON LAYING CAST-IRON WATER MAINS

To the Members of the New England Water Works Association:

In its 1953 report your Committee on Laying Cast-Iron Water Mains recommended the publication of the AWWA document, "A Tentative Procedure for Disinfecting Water Mains," AWWA designation "C601-53T," and of the paper, "Revised Main Disinfection Procedure," by Marshall P. Crabill, Chairman of the committee which developed the procedure and on which the NEWWA was represented. Subsequent to its approval as tentative by the Executive Committee of NEWWA, the "Procedure" was published in the June JOURNAL, accompanied by Mr. Crabill's paper.

Your committee recommends that the "Procedure" be adopted by the Association. Further, your committee calls attention to Mr. Crabill's paper, which it believes to be a valuable discussion of the "Procedure."

Your committee has no progress to report on specifications for laying water mains.

Respectfully submitted,

(*Signed*) W. S. MARINER, *Chairman*
GEORGE W. COFFIN

REPORT OF THE COMMITTEE ON SPECIFICATIONS FOR STEEL PIPE

October 4, 1954

To the New England Water Works Association:

This Committee of your Association acts jointly with Committee E7A of the AWWA on specifications for steel water pipe. At the annual meeting of Committee E7A on May 25, 1954, in Seattle, the proposed specifications for cement-mortar lining of steel pipe in place, with amendments, were adopted and recommended to the Water Works Practice Committee of the AWWA. The AWWA has approved these specifications and they will be printed in the October Journal of the AWWA. Your Committee recommends the adoption of these specifications by the New England Water Works Association.

Work will now get under way for revising existing Specification C205 on cement-mortar linings and coatings applied to pipe prior to field installation. A request was made for inclusion of lap-welded spiral pipe in AWWA Specification C202, and a subcommittee was appointed to study this matter. Recommendations were made by the Steel Water Pipe Manufacturers' Technical Advisory Committee for revisions to AWWA Specifications C201, C202, C203 and C204, and recommendations were made for the adoption of a tentative standard specification for steel pipe flanges in sizes over 48 inches to 96 inches. These recommendations will be handled by Committee E7A by letter ballot.

Respectfully submitted,

(*Signed*) THOMAS R. CAMP, *Chairman*
CHESTER J. GINDER

REPORT OF COMMITTEE ON STANDARDIZATION OF PIPE FLANGES AND FITTINGS

September 15, 1954

To the New England Water Works Association:

Committee B16 of the American Standards Association, upon which the undersigned are your representatives, deals with pipe flanges and fittings, including numerous types of screwed and bolted fittings, many of which are of little or no direct concern to water-works operators. If and when matters arise which are of interest, they will be called to your attention.

Yours respectfully,

(*Signed*) RICHARD HAZEN
ARTHUR L. SHAW

PROGRESS REPORT OF COMMITTEE ON DEEP-WELL VERTICAL PUMPS

September, 1954

To the New England Water Works Association:

The Committee on Deep-Well Vertical Pumps (NEWWA 39) presents the following report.

On February 12 the Committee received the Tentative Draft of Deep-Well Vertical Turbine Pump Standards, ASA-B-58, for review and comment. Reply was requested not later than March 15, 1954.

The Committee had three copies made of the standards, which it circulated to such members as it could locate who were interested in reviewing them. The following assisted in these reviews:

Dr. H. Carleton Moore—Chief Mechanical Engineer, Metcalf & Eddy, Boston, Mass.
Allen J. Burdoin—Senior Project Engineer, Metcalf & Eddy, Boston, Mass.
Clifford S. Mansfield—Fay, Spofford & Thorndike, Boston, Mass.
Baxter Robertson—Aetna Engineering Co., Boston, Mass.
Stewart S. Perry—Worthington Corporation, Boston, Mass.
Robert J. Walsh—D. L. Maher Co., Cambridge, Mass.

The comments of the various reviewers were compiled in the form of a letter and forwarded in March, 1954, to Mark H. Owen, Los Angeles, Cal., Co-Chairman of the ASA Committee B-58.

By letter of April 29, 1954, the Committee received a copy of a draft of corrections proposed to the tentative draft. We were pleased to note that a majority of our suggestions were incorporated in the corrections.

We have not been informed when the final draft will be submitted to the American Water Works Association for consideration.

The Committee is standing by to be of assistance if requested. Until the final draft is approved, we recommend the Committee be continued.

Respectfully submitted,

(*Signed*) EDWIN B. COBB, *Chairman*

REPORT OF THE COMMITTEE ON WATER RATE SCHEDULES

September 15, 1954

To the New England Water Works Association:

The Committee on Rates wishes to recommend to the Association the adoption of the report of the A.W.W.A. Committee on Rates* as the N.E.W.W.A. Committee report and recommends that the A.W.W.A. Committee report be printed in our JOURNAL in full.

Respectfully submitted,

(*Signed*) P. A. SHAW, *Chairman*
EDWIN T. MCDOWELL
WARREN GENTNER

*The report of the A.W.W.A. Committee on Rates is appended to this issue of the JOURNAL.

REPORT OF THE COMMITTEE ON CONSERVATION, DEVELOPMENT AND UTILIZATION OF WATER RESOURCES

To the New England Water Works Association:

Since August, 1951, the Committee on Conservation, Development and Utilization of Water Resources has carefully followed developments leading toward the establishment of a national water resources policy. In previous reports at the Annual Conventions your Committee discussed the report of the President's Water Resources Policy Commission, established by President Truman, and the work of the National Water Conservation Conference. In this connection no action has ever been taken by President Eisenhower on the controversial legislation prepared by President Truman's Water Resources Policy Commission or the subsequent legislation prepared by the Bureau of the Budget for President Truman. No further progress has been made by the National Water Conservation Conference in the preparation of legislation for a national water policy.

To undertake long-range programs of research and education to assure the resources essential to the progress, security and vigor of the nation, a non-profit organization was incorporated in 1952 under the name of "Resources for the Future". In December, 1953, Resources for the Future, Inc., held a Mid-Century Conference in Washington, D. C., to discuss the issues concerning our resources. Interest in the subject on a national scale was evinced by an attendance of over 1,500 persons representing all sections of the country. Since that time Resources for the Future, with a grant of $3,410,000 from the Ford Foundation, has undertaken a five-year program of research and education in the field of natural resources.

In August, 1953, the Eisenhower administration announced that its policy is to develop the national natural resources through cooperation of the States, local communities, private citizens and the Federal government, all working together. This policy was described as one which will not be a "monopoly by any one of these parties".

A Cabinet Committee on Water Resources Policy was established

in June, 1954, by President Eisenhower, to cooperate with Federal, State and private agencies "to conserve and best utilize the full potential of our water resources". Secretary of the Interior Douglas McKay was designated as Chairman of the Committee, which includes the Secretaries of Defense, Agriculture, Commerce, and Health, Education and Welfare, and the Director of the Bureau of the Budget. The latter three will serve only until the Committee report is filed in December, 1954. The Cabinet Committee has been instructed by the President to review the recommendations which the Hoover Commission will make in their comprehensive study of water and power policies and organization.

The President has also set up an Interagency Committee on Water Resources, which "will provide a facility for improving the coordination of existing policies, programs, and activities of the participating departments and agencies concerned with water and land resources investigation, planning, construction, operation and maintenance". Membership on this Committee will constitute officials from the Department of Interior, Department of Agriculture, Department of Commerce, Department of Health, Education and Welfare, the Department of the Army and the Federal Power Commission.

The President in a recent address at Los Angeles stated that important legislation to be considered by the next Congress will include a comprehensive water resources program.

Your Committee concurs with water resources authorities throughout the nation that there is an urgent need for a sound national policy for the development and conservation of our water resources, which will provide for the active cooperation and joint participation of individuals and industry, as well as local, State and Federal governments. In the implementation of such a policy, it must be recognized that the narrowing margin between the present supply of water and the amount ultimately available is going to require more knowledge, better engineering, and increased consideration of complicating factors on the part of all water users.

The question of Federal monopoly of power as against regulated local or private power appears to be developing into a major political issue in the forthcoming congressional elections. If the Federal monopoly advocates win, we may expect to see more rather than less

Federal control over our water resources. Your Committee believes that you should make your views known to your congressmen or senators before this problem gets out of hand.

Your Committee will continue its policy of keeping the Executive Committee advised of developments in this field, in order that the Association may be prepared to take any necessary or desirable action.

Respectfully submitted,

(*Signed*) THOMAS R. CAMP, *Chairman*
JOSEPH C. KNOX
BYRON O. MCCOY

PROGRESS REPORT OF COMMITTEE ON RECREATIONAL USE OF PUBLIC WATER SUPPLIES

October, 1954

In accord with the Suggested Procedure presented in the first report, the Committee is following the trends in various fields in regard to the multiple use of water supplies and watersheds and hereby reports on the same.

I. In the Field of Water-Supply Engineers

A Symposium on Views on Watershed Control appeared in the A.W.W.A. Journal for May, 1954. The following is condensed from same:

Edward S. Hopkins, Principal Associate Engineer, Bureau of Water Supply, Baltimore, Md.:

1. It is believed that, if recreational activities are under the direct supervision of the Water Department, undue sanitary hazards can be controlled, and the quality of the water delivered to the *purification plant* will not be seriously impaired. When control is invested in other agencies, there is inherent danger to the supply, especially if chlorination is the only purification measure.
2. Trend is to rely more on treatment.
3. When sedimentation and chlorination are the only treatments, extensive watershed control is warranted.
4. If source of supply is a large river or one of the Great Lakes, control of the watershed or boundary lands must be exercised by the State Health Department. The use of such water without treatment is not justified.

Roy E. Dodson, Jr., Sanitary Engineer, Water Department, San Diego, Cal.:

1. Better treatment is the obvious answer to higher standards of water quality.
2. Believes that the threat of encroachment of other land uses on watersheds should be used as a lever to hurry along better treatment facilities.
3. Water utilities should, of course, resist encroachment of a hazardous sort until adequate facilities for treatment are available.

Gordon L. Laverty, Assistant Sanitary Engineer, East Bay Municipal Utility District, Oakland, Cal.:

1. Improvements in treatment facilities do not, by themselves, constitute a sufficient argument for multiple use of water-supply reservoirs.
2. The degree of watershed control to be employed by a utility depends on local public sentiment, local topographic and weather conditions, and views of local engineering and health personnel.
3. Watershed use should be strictly controlled by those who are responsible for water-supply quality.
4. Those not charged with the safety of water supplies often endanger them in a measure commensurate with their lack of responsibility.

II. In the Field of Recreation Departments

From the same symposium as above:

Fred A. Thompson, Director of Fisheries, State Department of Game and Fish, New Mexico:

1. Those water consumers who object to multiple use of reservoir lands cite the hazards of contamination, etc. Author of the opinion that these dangers can be overcome by proper water treatment and adequate supervision of watersheds.
2. Obvious demand for additional recreational facilities will have to be met.

III. Consumer Opinion

There have been two definite indications in recent months as to how consumers feel about multiple use of water supplies:

1. Concord, N. H. Last fall councilors campaigned for election on the basis of opening Long Pond to recreational use. All of those who did were defeated soundly.
2. Manchester, N. H. In July of this year the Board of Water Commissioners saw fit to issue a general statement of their water-supply protection policy through the mails, in the face of a stepped-up campaign sponsored by the local paper to open Lake Massabesic to swimming. Return mail brought a representative response from people of all walks of life, including the medical profession, preponderantly in favor of the Board's present policy of limited use and strict control.

IV. Notes on Legislative Statutes Related to Control of Water Supplies

A. A review of statutes of some of the New England States has been conducted and generally they all cover the areas of concern.

B. The statutes vary from specific directives to a delegation of authority to make regulations with discretionary powers.

C. A review of past court cases and a discussion with legal counsel provide the information that specific directives are as a rule upheld in the courts, whereas regulations with discretionary powers are vulnerable, because of the necessity of proof that certain prohibited acts result in polluting a water supply to a dangerous degree.

Respectfully,

(*Signed*) C. L. AHLGREN, *Chairman*
F. O. A. ALMQUIST
S. S. ANTHONY
E. W. MOORE
C. I. STERLING, JR.
F. P. STRADLING
E. L. TRACY

REPORT OF COMMITTEE ON METHODS OF FINANCING WATER-MAIN EXTENSIONS

October 4, 1954

To the New England Water Works Association:

Your committee after study and discussion of their subject have come to the conclusion that, due to the wide variation in methods of financing water-main extensions, it would be advantageous not only to your committee, but also to the Association, to have an open discussion and therefore suggest that during the ensuing year your committee conduct a panel discussion on this subject at a Superintendents' Round-Table session. In this way we believe we shall be able to submit a more comprehensive and realistic report.

Respectfully submitted,

(*Signed*) KENNETH W. ROBIE, *Chairman*
ALLAN F. MCALARY
SHERMAN L. ROGERS

COMMITTEES OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1954-1955

N.E.W.W.A.—1. *Committee on Technical Programs:* Kenneth F. Knowlton, *Chairman,* Henry Campbell, G. Arthur Faneuf, Clifton E. Hodgdon, George C. Houser, Paul F. Howard, Edwin L. Jette, Robert W. Moir, Clarence H. Reed, Kenneth W. Robie and Harold B. Scales.

2. *Committee on Northern New England Meeting.*

3. *Committee on Southern New England Meeting.*

4. *Committee on Finance:* Thomas S. Lawrence, *Chairman,* James D. Halwartz and George N. Watson.

5. *Committee on Membership:* George W. Coffin, *Chairman,* John J. Baffa, Roland F. Burke, Clarence W. Metcalf, Howard H. Potter, Fred P. Stradling and Richard S. Woodhull.

6. *Committee on Library:* Ariel A. Thomas, *Chairman,* and Sydney C. Beane.

7. *Committee on Committees:* Roger G. Oakman, *Chairman,* Clarence L. Ahlgren, George G. Bogren, Stanley M. Dore, William B. Duffy, Allan F. McAlary, William P. Melley, Fred P. Stradling and Edward L. Tracy.

8. *Committee on Legislation:* Mark F. Croker, *Chairman,* Warren A. Gentner, William A. Healy, Philip J. Holton, Jr., Peter C. Karalekas, Edwin T. McDowell and Edward L. Tracy.

9. *Committee on Reciprocal Relations with the Institution of Water Engineers* (England): E. Sherman Chase, *Chairman,* Leland G. Carlton and Percy A. Shaw.

11. *Committee on Survey of Ground Water Supplies in New England:* Francis J. Lariviere, *Chairman,* M. L. Brashears, Jr., Henry N. Halberg, Howard H. Potter, Walter J. Shea, Leslie K. Sherman, Ralph M. Soule, Hyman J. Steinhurst and Edward L. Tracy.

12. *Committee on Rainfall and Yield of Drainage Areas:* Francis H. Kingsbury, *Chairman,* Peter C. Karalekas, Karl R. Kennison, Harvey B. Kinnison, Francis J. Lariviere, Ralph M. Soule, Miner R. Stackpole, Hyman J. Steinhurst, Harold J. Toole, Howard M. Turner and William A. D. Wurts.

16. *Committee on Coefficients for Friction in Pipe Lines:* Richard H. Ellis, *Chairman,* E. Shaw Cole, F. W. Haley, Byron O. McCoy and William E. Stanley.

19. *Committee on Water Quality and Treatment:* Edward W. Moore, *Chairman*, George G. Bogren, Edward S. Brown, Jr., Clair N. Sawyer, Warren J. Scott and David H. Turcotte.
21. *Committee on Specifications for Cast-Iron Pipe and Fittings* (Sectional Committee under American Standards Association): Arthur L. Shaw and Richard Hazen.
22. *Committee on Reinforced Concrete Pressure Pipe* (Joint with American Water Works Association): Stanley M. Dore, *Chairman*, George W. Coffin and Herman G. Dresser.
23. *Committee on Code for Pressure Piping* (Joint with American Society of Mechanical Engineers): Thomas F. Wolfe.
24. *Committee on Laying Cast-Iron Pipe* (Joint with American Water Works Association): W. Seward Mariner, *Chairman*, and George W. Coffin.
25. *Committee on Specifications for Steel Pipe* (Joint with American Water Works Association): Thomas R. Camp, *Chairman*, and Chester J. Ginder.
26. *Committee on Standardization of Pipe Flanges and Fittings* (Sectional Committee under American Standards Association): Arthur L. Shaw and Richard Hazen.
28. *Committee on Steel Standpipes and Elevated Tanks* (Joint with American Water Works Association): George A. Sampson, *Chairman*, Herman Burgi, Jr., Henry E. Halpin and Joseph C. Lawler, Jr.
30. *Committee on Meter Specifications* (Joint with American Water Works Association): Reeves Newsom, *Chairman*, Frank S. Brainard and Richard H. Ellis.
32. *Committee on Gate Valves* (Joint with American Water Works Association): Harold W. Griswold, *Chairman*, and Leland G. Carlton.
37. *Committee on Federal Activities* (Joint with American Water Works Association): Clarence I. Sterling, Jr.
38. *Committee on Fluid Permeability* (Sectional Committee under American Standards Association): Stanley M. Dore.
39. *Committee on Deep-Well Vertical Pumps* (Sectional Committee under American Standards Association): Edwin B. Cobb.
42. *Committee on Conservation, Development and Utilization of Water Resources:* Thomas R. Camp, *Chairman*, Joseph C. Knox and Byron O. McCoy.
44. *Committee on Publicity:* Peter C. Karalekas, *Chairman*, Clarence L. Ahlgren, Frederick O. A. Almquist, Charles B. Hardy, William H. McGuinness and William A. D. Wurts.

45. *Committee on Recreational Uses of Public Water Supplies:* Clarence L. Ahlgren, *Chairman,* Frederick O. A. Almquist, Sidney S. Anthony, Edward W. Moore, Clarence I. Sterling, Jr., Fred P. Stradling and Edward L. Tracy.
46. *Committee on Plastic Pipes and Plastic Linings for Water-Supply Uses:* Joseph A. McCarthy, *Chairman,* Dwight L. Agnew, Martin E. Flentje, Charles B. Hardy and I. Laird Newell.
47. *Committee on Methods of Financing Water-Main Extensions:* Kenneth W. Robie, *Chairman,* Allan F. McAlary and Sherman L. Rogers.

Determination of Water Rate Schedules

Committee Report

A report of AWWA Committee A4.B—Water Rates, originally published in Journal AWWA, Vol. 46, pp. 187–219 (Mar. 1954).

THE subject of water rates has been involved in controversy for several decades, and it is not possible to resolve this controversy now by any simple set of rules. Not only are divergent views concerned but differences in local conditions, laws, ownership (public or private), control (commission or local), and other matters must also be considered. As many of the issues have already been reviewed by the committee in recent JOURNALS (*1–4*), only those aspects which have a bearing on committee recommendations are included in the text of this report.

In view of the circumstances, the report is aimed at outlining the basic elements involved in water rates and suggesting *alternate* rules of procedure for formulating rates, thus permitting the exercise of judgment and preference to meet local conditions and requirements.

The subject matter is presented in four sections:

Section 1—Amount of Revenue: Amount of revenue may be determined by either of two methods of approach: the utility basis and the cash basis. The applicability of each basis is discussed, and illustrative applications are presented showing the possible range in total revenue, depending on the basis used and the assumptions adopted.

It is suggested that the income from rates in suburban areas should be determined on the utility basis.

Section 2—Classification of Costs: Costs are considered on *two* bases: the common basis required by the *demand*

theory of rates, which allocates expense to capacity or demand, output, and customer costs; and the *functional* classification of costs into production, distribution, customers' service, fire, and special costs. Modified rules are suggested for the classifications under the demand basis, and an illustrative application of the functional distribution of costs is presented.

Section 3—Allocation of Expense: Allocation of expense between water users and taxpayers, and between the several classes of normal and special users, is considered. The wide range of opinion on the portion of the water works burden that should be assessed to property is noted, and practicable limits are suggested for the income to be derived from taxes, assessments, or other levies on property.

Fire protection is treated as a special use, and an attempt is made to suggest methods for the computation and collection of reasonable fire charges without recourse to an unacceptable increase in the tax burden.

Sprinkling, air conditioning and refrigeration, and other special demands that increase the peak load are in some areas placing an increased burden on water systems. To control such demands and to distribute the additional costs more equitably, demand charges are suggested and illustrated.

Section 4—Rate Schedules for Normal Users: An attempt is made to present definite rules for the formulation of rates which will distribute normal expense among *all* customers, as nearly as possible in proportion to the cost of supplying the commodity. Special users whose intermittent demands require excess plant would pay these normal rates for all water used, plus additional demand charges as suggested in Section 3.

Methods or rules for determining rate schedules are developed on two bases: the demand (or capacity) basis and the functional (or customer cost) basis. Both of these bases have been used for many years, but their applications have been the cause of much of the controversy in rate making. The demand basis was outlined in the *Manual of Water Works Practice* (*5*) in 1925, and the functional or customer cost basis generally follows a committee report (*6*) adopted by AWWA on May 24, 1923. The principal difference between the two bases involves the amount of the service charge—whether it should include a substantial portion of demand or ready-to-serve costs, or be limited to customer costs only. Rules are proposed herein that may help to reconcile the two bases and permit the use of either theory, with comparable results.

Section 1—Amount of Revenue

Every water works should receive a gross revenue in an amount that will suffice to provide adequate service and assure the maintenance, development, and perpetuation of the system.

Two bases for the determination of revenue have been used widely, and each has its particular field of application. They may be called the "utility" basis and the "cash" or budget basis (*3, 7*).

Utility Basis

The utility basis is required for all privately owned water works and for the relatively few publicly owned systems under the control of state commissions or other outside regulatory

authorities. State commissions exercise jurisdiction over municipally owned water works in the regulation of rates within corporate limits in six states: Maine, Montana, Nevada, West Virginia, Wisconsin, and Wyoming (*8*).

The utility basis requires the determination of a rate base, or the amount of capital upon which the utility is entitled to earn a return, and the fixing of a fair rate of return on the rate base.

The gross revenue, on this basis, would therefore include: operation and maintenance expense; taxes; depreciation; and a return on the rate base.

Operation and maintenance expense are a matter of record and experience. Assuming equal efficiency in management, the amount is independent of the type of ownership or control of the utility.

Taxes collected through revenue by the privately owned utility must include all taxes which the utility is obligated to pay to federal, state, and local governments. For the publicly owned water works, the tax item may vary from none to all of the taxes required of the privately owned system, although in the publicly owned utilities where allowances are made for this item, the amount is often limited to local taxes.

Depreciation allowances are based on such annual percentages of the items of plant investment as may be considered necessary to accumulate the amount of the corresponding capital at the end of the useful life of the physical property. Under commission control, rates for depreciation are fixed or approved by order and are adjusted from time to time to accomplish their objective. Privately owned utilities are generally restricted in the use of depreciation funds. Relatively small amounts of cash are usually held in "working capital," and the balance may be invested in plant extensions. The use of such funds to retire debt is not permitted.

Frequently, with publicly owned and locally controlled properties, rates of depreciation are larger than necessary for normal replacements and extensions, and the surplus accumulated from this and other sources is used for major improvements, for debt retirement, or as a donation to the general fund of the municipality.

The *rate base* and *rate of return* are matters determined by court or commission decisions for all utilities subject to such control. For all publicly owned and locally controlled water works, no such machinery is available, and the determinations are made by local authorities, with or without the aid of consultants, accountants, or other experts. It is not uncommon, in such instances, for municipalities to use the so-called book value, where the figures exist, or the actual cash expenditures over the years, with or without the interest accumulations on property paid for out of bond issues.

Courts and commissions determine rate bases quite differently in the various states. The methods range from original cost (or prudent investment) less depreciation, which is recent practice with many commissions, to present reproduction cost less depreciation (or fair value), which is required by statute in at least one state. Obviously, a commission must fix a rate base and rate of return for a privately owned utility that will assure an income sufficient to attract the capital necessary to maintain and develop the corporation.

For the publicly owned and locally controlled water works, the rate base

and rate of return are not significant items in connection with financing. Money is borrowed on general-obligation, special-assessment, or revenue bonds. General-obligation or special-assessment bonds have a lien on all or a portion of the property in the city and are not affected by the value of the assets or the earnings of the water works. Revenue bonds are secured by a lien on the earnings of the water works, but the buyer is not especially interested in the value of the property involved. Rather, he is concerned with the net operating revenue available for interest and debt retirement.

If the gross revenue of a publicly owned water works is computed on the utility basis, the rate base and rate of return should be comparable to those of a privately owned property. The Wisconsin Public Service Commission is required by statute to adopt the basic principle that "a municipally operated water utility is entitled to the same rate of return as that permitted for privately owned utilities" (*9*). By the same logic, it seems proper to assume that a publicly owned property is not entitled to earn a higher rate than that which would be permitted a comparable privately owned property. A recent decision of the Wyoming commission ruled that a "municipal water plant is not entitled to as high a return as utility companies" (*10*), while, in Maine, it is reported that, "theoretically, a water district is not entitled to any 'return' or net income, but the commission always allows some leeway for contingencies or emergencies" (*11*).

From the record available (*12*), it appears, however, that the rate of return on book value varies in municipally controlled water works from no return to more than 20 per cent. This range is due chiefly to four factors: [1] amount of outstanding debt; [2] inaccurate records of book value; [3] appropriations for major improvements; and [4] diversions of water works funds to meet deficiencies in other municipal departments.

It is obvious that the revenue requirements of most municipally controlled water works are not premised on any rate base or rate of return, but on the cash requirements of the system, as determined by local conditions and policies. Hence, a cash basis affords an alternative and more realistic approach to the problem for the great percentage of municipal water works.

Cash Basis

The cash basis is similar to the budget basis of other city departments and, as such, is more easily explained and justified to city administrations. The total revenue is based on estimates of cash requirements, supported by operating experience and knowledge of future needs.

The items to be included may be separated into basic and optional classifications. The basic items are: operation and maintenance; debt requirements (interest and principal); replacements; and normal extensions and improvements. The optional items are: taxes; appropriations for major improvements, or reserves therefor; and contributions to other city departments. The basic items cover the essential requirements concerning which no water works manager, council, or commission will disagree; but the optional or additional items involve matters on which there is much difference

of opinion and which, in the last analysis, will be decided by local authorities.

Debt requirements should include the interest and repayment of all outstanding bonds—whether general obligation, special assessment, or revenue—the proceeds from which have been invested in water works property. Replacement estimates should be sufficient to provide for the current renewals and replacements of such units of equipment and property as are no longer serviceable and need to be replaced or rebuilt. The allowance for normal extensions and improvements should provide for the year-to-year costs for small main extensions, services, meters, hydrants, and similar minor items, but should not include sums to be set aside for major improvements. This item, together with that for replacements, may often be substantially equivalent to normal depreciation allowances. Taxes are controversial, but majority opinion would probably favor payments to the municipal government in lieu of all local taxes, provided the municipal government makes a reasonable payment to the water department to cover the fire protection service. If it is local policy to avoid debt, partially or entirely, in meeting the cost of major improvements, a reserve may be created and the corresponding funds kept apart, carefully invested and earmarked, without possibility of diversion for other purposes. Such a reserve may not, however, be legal in all states.

Diversion of water works funds to other city departments is the most controversial item among the optional additions to revenue. Although the practice is common, particularly in the larger cities and those in which normal property taxes yield inadequate revenue, it may be deprecated by persons concerned with the best interests of the water works. The danger inherent in such a practice is that, once adopted as a policy, it affords an opening wedge for further claims on water works revenue to the point of injury to water service. Striking illustrations of the inadequacy of existing water facilities due to fund diversions are common knowledge.

Illustrative Applications

The following applications illustrate the range in revenue determination using the two bases and with varying assumptions regarding the items involved. The figures are based on the records of a city of 100,000 population with a book value of approximately $8,400,000. In 1950 this municipality had a gross annual revenue of $490,564, paid no taxes, had a debt service charge of $51,125, and made an appropriation of $90,536 for extensions and betterments.

On the cash basis, therefore, this property operates with a gross revenue about as follows:

Operation and maintenance	$259,000
Debt requirements	51,125
Replacements, extensions, and improvements	90,536
Net income (1.07 per cent of $8,400,000)	89,903
Total revenue	$490,564

The minimum revenue, on the cash basis, for such a property could be the sum of the first three figures, or $400,661; and the maximum revenue probably should not exceed this latter sum, plus local taxes at 1½ per cent, plus perhaps 6 per cent on the book value, or a total of $979,536:

Operation and maintenance	$259,000
Replacements and extensions	90,536
Taxes at 1½ per cent	126,000
Major improvements or fund diversions (6 per cent of $8,400,000)	504,000
Total revenue	$979,536*

On the utility basis, one might estimate the revenue as follows:

Operation and maintenance	$259,000
Depreciation (1¼ per cent)	105,000
Taxes (1½ per cent)	126,000
Return (6 per cent)	504,000
Total revenue	$994,000

Next, assume the same property to be privately owned, with these figures applying: rate base, approximately $7,000,000 (or $8,400,000 less accumulated depreciation, plus working capital); annual depreciation allowance, 1¼ per cent of $8,400,000; local taxes, 3 per cent; federal income taxes, $304,000; and rate of return, 6 per cent of fair value (based on $3,500,000 in bonds at 4 per cent and $3,500,000 in stock at 8 per cent). The gross revenue then becomes:

Operation and maintenance	$259,000
Depreciation (1¼ per cent)	105,000
Taxes (3 per cent)	210,000
Return (6 per cent)	420,000
Federal income taxes	304,000
Total revenue	$1,298,000

* In Maine, "the revenue for the utility illustrated would be determined about as follows:

Operation and maintenance	$259,000
Taxes	0
Depreciation (1¼ per cent on $8,400,000)	105,000
Interest on indebtedness (4 per cent on $3,500,000)	140,000
Sinking fund provision (minimum, 1 per cent on $3,500,000)	35,000
Minimum revenue requirement	$539,000

"This minimum is often adjusted by the commission to allow the district to retire its indebtedness at a more rapid rate and to provide for foreseeable future increases in operation and maintenance" (*11*).

If the rate base were set at fair value, instead of prudent investment, the gross income requirement could be materially larger, depending upon the average age of the property, the allowable rate of return, the amount of taxes, and other elements.

The preceding figures demonstrate the wide range of total revenue (from $400,661 to more than $1,298,000) possible under the alternate assumptions, depending upon type of ownership, rate base, and rate of return (for privately owned utilities), and (for publicly owned and controlled properties) such matters as payments in lieu of taxes, financing methods, and contributions to other municipal functions.

Revenue From Suburban Areas

The rates to suburban areas should be computed on the utility basis. The assumption may be made that the water works is the property of the citizens of the municipality and that users outside of the city should pay a rate that, if applied to all such users, would provide for all operation and maintenance expense, plus local taxes, depreciation, and a reasonable return on the value of such portions of the property as may be devoted to the service of the outside areas, including all production and transmission facilities required to deliver the product to the city limits, but excluding the distribution, service, and fire facilities provided solely for serving the area within the city. The sum of all such costs, divided by the total annual production less transmission losses, gives an average sale price applicable to all outside users with normal load factors.

On such a theory, if the utility basis is used inside the city, as is done by

privately owned systems, or by publicly owned systems under commission control, there is no difference between city and suburban rates, except for charges that may be justified as extra costs in particular situations.

Section 2—Classification of Costs

In order to formulate rate structures, costs must be classified in some manner to permit their allocation to the several services and users. Two methods—the demand basis and the functional cost basis—are presented herein.

Demand Basis

It has been a general practice to divide costs into three groups: customer costs, capacity costs, and commodity costs. Customer costs include those arising out of the maintenance of services and meters and the labor and accounting expense required for reading, billing, and collecting. Customer costs constitute a relatively small proportion of the total. They are readily segregated, as are also the direct charges to fire protection, arising out of hydrants and their connections, and any other equipment provided solely for fire and for special purposes. Based on the usual definitions, capacity costs include those which arise out of providing plant and keeping it "ready to serve." Commodity costs are those which vary directly with the amount of water produced. The separation of capacity from commodity costs has, however, long been a subject of controversy. Strict compliance with these commonly quoted definitions leads to classifying a very large percentage of all costs as capacity costs and a relatively small percentage as commodity costs.

The theory upon which this practice is based was inherited from the electrical industry. It was originally set out by Hopkinson in England and by Henry L. Doherty in this country, treating of rates for electricity supply:

> [Based on this theory, the] cost of central station service can be generally divided into three classes:
>
> 1. Those elements of cost which are strictly proportional to the number of customers, such as billing, meter reading, accounting, collecting, meter testing, etc.
> 2. Those elements of cost which are proportionate to the maximum demand which a customer may make upon the plant and system of the public utility.
> 3. Those elements of cost which are in proportion to the actual amount of water, gas, or electricity actually used.
>
> Any system of rates which omits from proper consideration any great proportion of the costs referred to above results in an overcharge to some and too great liberality to others (*13*).

This theory needs to be modified for satisfactory application to water works. One aspect of the water works industry that differentiates it from other kinds of business is the relatively large proportion of the costs that are fixed, in the sense that they do not vary with output. Theoretically, almost all costs, except such items as coal, electricity, and chemicals, can be so classified. In the illustration presented later in this section (page 10), the capital costs alone, based on only 6 per cent of the capital investment to cover fixed charges, amount to about two-thirds of the total annual charges. Examples might be cited in which a very large percentage of total costs has been allocated to capacity costs. It is not uncommon to find nearly half the total expense assessed to customers as a demand or capacity charge and collected through a service or a minimum charge, or in a higher unit rate for the first step—in effect, a substantial

charge largely independent of the flow through the meter.

The *Manual of Water Works Practice* (*5*) considered this dilemma in 1925 and concluded that capacity costs computed in this manner would amount to "a considerable proportion of the total cost" but that "theory should not be carried to extremes, and, regardless of calculation, it is best to limit the service (capacity) charge in all cases to reasonable amounts. . . . [The] consumption (commodity) charges should, in all cases, carry the major part of the entire cost of service."

In an effort to bring uniformity in the classification of costs by this method, the committee suggests the following modified definitions:

Customer costs: These costs shall comprise all operation and maintenance and fixed charges arising out of service to customers, including meters and services, collection, and commercial expense, together with a suitable portion of general and administrative expense.

TABLE 1

Distribution of Capital

Item	Production and Transmission $	Distribution $	Customers' Facilities $	Hydrants and Connections $	Office $	Stores and Shop $
Organization					10,000	
Land and rights	93,000				50,000	70,000
Structures and improvements	590,000	150,000				
Power production equipment	44,000					
Steam pumping equipment	34,000					
Electric pumping equipment	220,000					
Purification equipment	59,000					
Plant in progress	318,000					
Transmission mains	1,730,000					
Feeder mains in progress	175,000					
Distribution mains		3,680,000				
Hydrants				332,000		
Office furniture and equipment					22,000	
Transportation equipment						45,000
Stores equipment						2,000
Shop equipment						6,000
Laboratory equipment						3,000
Tools and work equipment						17,000
Meters and services			750,000			
Subtotal	3,263,000	3,830,000	750,000	332,000	82,000	143,000
Distribution of office and shop	45,000	67,500	90,000	22,500		
Total	3,308,000	3,897,500	840,000	354,500	225,000*	

* Office and stores and shop distributed as follows: production, 20 per cent; distribution, 30 per cent; customers, 40 per cent; and hydrants, 10 per cent.

Capacity costs: These costs shall be limited to a portion only of the fixed charges of depreciation, taxes, and return. After suitable deductions for fire protection, customers' investment, and property devoted to special uses, the remaining fixed charges shall be divided between the capacity costs and

TABLE 2

Distribution of Operation and Maintenance Costs

Item	Production and Transmission $	Distribution $	Customers' Facilities		Hydrants and Connections $	Office $
			Commercial $	Meters and Services $		
Source of supply						
Labor and expense	12,300					
Maintenance	3,100					
Power and pumping						
Labor	21,000					
Power	93,700					
Miscellaneous	6,900					
Maintenance	3,300					
Purification expense						
Labor	1,100					
Chemicals	9,100					
Miscellaneous	200					
Maintenance	400					
Transmission	5,000					
Distribution						
Labor		14,000				
Miscellaneous		3,000				
Maintenance		8,000				
Hydrants					3,600	
Services				5,900		
Maintenance, general structures		300		200		500
Meters				4,900		
Customer accounting			45,200			
Administrative and general						17,300
Subtotal	156,100	25,300	45,200	11,000	3,600	17,800*
Distribution of office	3,560	5,340	5,340	1,780	1,780	
Total	159,660	30,640	50,540	12,780	5,380	

* Distributed to: production, 20 per cent; distribution, 30 per cent; commercial, 30 per cent; meters and services, 10 per cent; and hydrants, 10 per cent.

the commodity costs of normal users on a basis to be determined.

Commodity costs: These costs shall include all operation and maintenance expenses, except those chargeable to customers and to fire protection or other special services, plus the balance of the fixed charges not allocated to capacity or customer costs.

The application of the customer, capacity, and commodity costs to the formulation of rate schedules is discussed in Sections 3 and 4. The procedures for designing water rates have generally been based on trial-and-error assumptions applied to the sales records of the particular community. In Section 4, suggested procedures are presented.

Functional Cost Basis

An alternative method of classifying costs, which permits the establishment of definite rules for determining water

rates, is a functional distribution, as proposed in a Michigan Section committee report (*1*). In this method, operation and maintenance, as well as fixed charges, are separately allocated to the functions of: production, including source, treatment, pumping, and transmission; distribution; customers' services and meters; and hydrants and connections. Office and shop costs are first separately classified and then distributed by judgment to the four main classifications.

TABLE 3

Summary of Capital Investment and Operating Cost

Item	Capital Investment $	Operation and Maintenance $
Production and transmission	3,308,000	159,660
Distribution	3,897,500	30,640
Subtotal	7,205,500	190,300
Customers' facilities	840,000	63,320
Hydrants and connections	354,500	5,380
Total	8,400,000	259,000

By this means it is possible to provide the data upon which a distribution of costs may be made, first to fire protection (and any other charges to property) and, second, to special and low-load factor users, as discussed in Section 3. The balance of the costs are then allocable to normal users, through a service charge and commodity rates, in accordance with the specific rules outlined in Section 4.

Illustrative Applications

A typical distribution of capital and of operation and maintenance costs for a city of 100,000 population, with a book value of $8,400,000, is shown in Tables 1–4. These tables provide the bases for the allocation of expense in Section 3 and the determination of rate schedules in Section 4.

The figures presented in Table 3, which summarizes Tables 1 and 2, make possible the allocation of costs to fire protection and special users (Section 3) and to normal customers (Section 4). To derive from Table 3 the annual costs against each classification of service, the desired or necessary gross revenue must first be determined by the methods outlined in Section 1. In the particular city from which the figures are taken, the gross revenue was reported as $490,564, leaving only $231,564 in excess of the costs of operation and maintenance shown in Table 3, or only about 2¾ per cent of the total investment. This property has substantially no debt, pays no taxes, and receives no payment for fire protection.

TABLE 4

Annual Charges

Item	Fixed Charges $	Operation and Maintenance $	Total $
Production and transmission	198,480	159,660	358,140
Distribution	233,850	30,640	264,490
Subtotal	432,330	190,300	622,630
Customers' meters and services	50,400	63,320	113,720
Hydrants and connections	21,270	5,380	26,650
Total	504,000	259,000	763,000

For the purposes of this discussion and the illustrative examples which follow, it has been assumed that the income received by this property should pay fixed charges of 6 per cent on the total investment plus the total expense for operation and maintenance. Obviously, the percentage figure used should yield the amount required by the specific utility to cover depreciation, taxes, and return. Assuming 6 per cent, the total income would be $763,000, allocated to functions as in Table 4.

Section 3—Allocation of Expense

This section considers briefly the questions involved in the allocation of expense between water users and taxpayers and between normal water users and special, or low load factor, users.

Water Users and Taxpayers

In most municipalities today, the water works performs more than one function. Generally, its primary function is to supply a necessary commodity to its customers, but it also affords certain benefits to the municipality as a whole. It safeguards public health, improves property values, and contributes to fire protection. Except for fire protection, which is dealt with below as a low load factor use, these benefits are intangible and their values are not determinable by rule. Whether or not they should bulk large in the allocation of expense is a matter upon which there is a difference of opinion.

Although it has been the practice in many publicly owned water works to allocate some part of the annual expense—usually some portion of the debt service—to the taxpayers, such allocations have been the result of the methods of financing rather than any theory of benefits. Financing has depended on local conditions and on the most advantageous method of borrowing or assessing costs, without any particular consideration of equity in the division of the financial burden between the water users and the taxpayers.

Prior to about 1920 most municipally owned water works were financed through the sale of general-obligation or special-assessment bonds. To the extent that the interest and bond retirement payments were taken from taxes, the practice constituted a contribution by property to the cost of the water works. In many cities, however, the debt service on these bonds was met out of the revenue from rates, with little or no contribution from the taxpayers. In fact, taxpayers have commonly been the beneficiaries of much free service, including water to public buildings, street and sewer flushing, fire protection, and cash diversions to the general fund.

During the past two decades much municipal water works financing has been accomplished through the sale of revenue bonds, supplemented by surplus cash from earnings. Normally, all of these funds come from water users, except where a fire protection charge is included in the tax budget. It is common practice, however, to finance extensions to the distribution system by assessments, or the equivalent, on the property to be served.

A recent suggestion (*7*, page 175) that would allocate a considerable part of the annual expense to the taxpayers proposes the "use of *general* tax funds to finance at least a part of the con-

struction or replacement of *major* structures," and the "use of *special* assessments to finance acquisition, construction, or replacement of *local* structures," with the "use of water charges to finance operation and maintenance" only. The rules for applying this plan are sufficiently clear to permit their use in practice.

Others (*14*) have proposed allocations of costs on a nearly equal basis between taxpayers and water users, but the principles supporting the logic of such allocations have not been presented.

Although there are situations in which it is necessary to make considerable use of the taxing power in order to finance new systems or provide major improvements for existing ones, these instances are exceptions rather than the rule. Such situations generally arise when it is desired to develop a water system in advance of the arrival of the anticipated customers (who may be expected later to use the system and pay the cost through rates). Reliance on the taxing power may also be dictated for utilities whose fixed charges are a preponderant part of the total cost of service. For example, in the financing of water and sewage services to such an area as the Washington Suburban Sanitary Dist., involving 200 sq miles of territory with a population of only 250,000, it has been necessary that property assume a substantial portion of the burden; or in the development of a remote and expensive source of supply, like that of Los Angeles, the financing of a major part of the cost must be based on a guarantee from property.

Generally speaking, however, the presently developed and established water systems need little or no financial assistance from taxes. A large proportion of such systems are able to collect through reasonable rates a sufficient income to operate, maintain, and develop adequate facilities. At the same time, many cities are hard pressed to find sufficient property tax revenue to meet the increasing costs of other municipal services and are seeking additional sources of income. Under these circumstances, it would seem to be unrealistic to propose generally that any considerable amount of utility revenue be collected through property taxes as payment for intangible benefits to property as a whole, no matter how alluring the theory upon which such proposals are based.

Although the sources of water works revenue are to be determined on the basis of all local factors, one may conclude that most of the income will be derived from the water users and that the portion received from taxes, assessments, or other levies will usually be limited to: fire protection; assessments on benefited property for main extensions; and occasionally some tax aid, grant, or donation to help finance a major improvement.

The preceding comments are intended to apply primarily to publicly owned and locally controlled water works. Publicly owned systems controlled by commissions are usually subject to the same regulations as privately owned properties. Gross earnings from utility rates, plus a fire protection charge, provide for operation and maintenance, depreciation, and taxes, as well as a limited return on the rate base; and, out of net earnings, the equivalent of dividends is frequently paid to the general funds of the city. Commission rulings appear to deny the right of cities to accumulate,

through rates, the surplus necessary to finance future major improvements.

Except for public fire protection charges, privately owned water works have no "legal authority . . . to make any charge or assessment against nonusers" (*7*, page 228). To a limited degree, however, privately owned systems extend lateral mains with the aid of customer contributions or deposits, subject to later refund, or through rate surcharges sufficient to meet the added expense.

Normal and Special Users

Users may be divided into normal and special classes, based on the ratio of their maximum demand to the average annual rate of use. Most water users may be assigned to the normal category, but there appears to be an increasing number of special users whose maximum demand, in relation to the average, is higher than normal because of seasonal or intermittent use. Among special uses one may include fire protection, air conditioning and refrigeration, lawn sprinkling, supplies to golf courses, other irrigation supplies, and those for certain commercial and industrial purposes.

Special users, except where the demands are offpeak, require more plant capacity in relation to average use than do the normal users. Hence, the cost of service to such special users is greater than for normal users by the amount of the fixed charges on the additional plant required.

Generally, single rate schedules have been applied heretofore to all types of water users, without regard to demand in relation to use. In recent years, in some areas, the summer use of water for sprinkling and the nonconserved use for air conditioning have placed such an increased burden on water systems that adjustments in water rates are desirable if each user is to pay for his service, as nearly as practicable, on the basis of cost.

To accomplish these adjustments, information is needed on the maximum-day demand assignable to each class of service—to domestic use, sprinkling, air conditioning, commercial and industrial use, and fire protection. On the basis of an allocation of plant capacity to normal and special users (including fire protection as a special use) fixed charges may be allocated to each use, either through an additional demand or service charge or through a modification of the rate structure.

Fire Protection

Numerous methods have been proposed in the past for determining the proper portion of water works costs chargeable to fire protection. Three of these methods, together with a discussion of some of the basic controversies involved in their application, have already been presented by the committee (*3*): the classic method of Metcalf, Kuichling, and Hawley (*15*), published in 1911; a method outlined in 1913 by Erickson (*16*), of the Wisconsin Public Service Commission, and elaborated upon by Alvord (*17*) in 1914; and the more recent basis employed by the Wisconsin commission, as described by Nixon (*18*) in 1937.

Two fundamentally different theories are involved in these methods. One theory (*15, 18*) assumes that the share of the applicable fixed costs chargeable to fire protection may be based on the ratio of the fire demand to the total demand for water, including fire, but that only the incremental operating and maintenance costs are to be included.

The other theory (*16, 17*) considers that both fire and general service should bear the burden of cost (both fixed and operating) "according to an apportionment of the existing plant based upon the relative costs of entirely separate systems" (*17*).

Under the first theory, the charge to fire is a relatively large proportion of the fixed costs in a small community and decreases with increased population. On the Kuichling basis, the percentages could vary, for example, from 77 per cent of the fixed costs with 5,000 population down to 13 per cent with 300,000 population, and include "between 5 and 10 per cent of the total annual operation and maintenance charge." It will, of course, be realized that percentages based on 1911 data may not apply today.

Under the second theory, nearly half of all fixed and operating costs, regardless of the size of the city, are chargeable to fire protection. Although, in earlier years, there were a few commission allocations (*19*) in which the revenue from fire approached 50 per cent of gross revenue for small towns, there has never been any general acceptance of the "separate-system" basis of allocation.

The application, by individuals and commissions, of these and other theories on the determination of the fire charge has led to widely varying results and has been the subject of controversy for four decades. Although most water works managers and engineers have generally accepted the propriety of charging for public fire protection, and courts and commissions have usually included allowances for this service in rate structures, such a charge is lacking in most municipally controlled water works. Privately owned properties usually charge for fire protection, but frequently in nominal amounts only.

Among the factors that have contributed to this state of affairs are: [1] a general feeling that the theories of computing the fire charge have overemphasized the cost of this service; and [2] the fact that a fire charge has been an additional item in a tax budget which is already inadequate for other municipal needs. Under such circumstances, if one hopes to effect any improvement in a confused situation, a more realistic approach is required, both in the method of computing the fire charge and in the manner of its collection.

In computing the charge, one should accept the premise that the prime function of the average municipal water works today is to supply a commodity, and that fire protection, although important to the safety of the community, is a supplementary service, the charge for which should not exceed the demonstrable additional costs involved in rendering this service.

The *direct* additional costs include: [1] the fixed and operating charges arising out of all plant and equipment installed solely for fire protection, such as hydrants and their connections and any pumps, mains, storage, or other equipment used only for fire service; and [2] the cost, at normal commodity rates, of the water used in fighting fires.

The determination of *indirect* costs —those costs that arise out of the additional plant capacity required for fire protection—has been a difficult hurdle in the past. The mechanics of this determination, particularly as applied to distribution facilities, have been com-

plicated even more by the improved definition of fire demands. Before 1948 it had been generally assumed that total fire demand was based on population in accordance with the standard schedule of the National Board of Fire Underwriters, adopted Dec. 14, 1916. Then the NBFU issued Bulletin 266, in which the character of the area protected, the degree of congestion, the size of the buildings, and the type of occupancy were taken into account, so that "material modifications" had to be made in many instances (*20*). The total fire requirements are now based on the extent of a mercantile district or on the size of and conditions surrounding industrial sections or areas of high-value buildings. Although 20,000 gpm remains "the maximum fire flow demand required in any city," regardless of population, "communities suburban to a metropolis," for example, may not need nearly the fire flow called for by the formula. Over much of the distribution system, the fire requirements may vary from as low as 500 to 1,500 gpm in single-dwelling residential areas; from 1,500 to 3,000 gpm in sections with individual apartment houses, schools, hospitals, or single factories; and up to 6,000 gpm in densely built residential areas.

It appears, on the basis of this modified concept of fire demand, that the indirect additional or incremental costs of fire protection cannot be determined with any degree of precision by the application of a ratio of fire demand to total demand applied indiscriminately to the annual charges of all or even the major parts of a water works property. Rather, this determination requires a subdivision of the cost of the property into two parts: those items needed for general service without provision for fire protection, and those that must be added in order to provide for both classes of service. This subdivision is simplified for the production facilities by certain basic considerations. Where the source of supply is a large reservoir, no part of the cost of such storage would be chargeable to fire. To the extent that excess clear well storage relieves treatment facilities, the ratio applied to such investment may be reduced. A proper charge for distribution storage should be made, however; and the pumping plants that deliver water into the distribution system may be apportioned on the basis of the relative demands of fire and other services.

The additional cost of distribution facilities may account for much of the cost of fire protection. An accurate determination would require cost estimates based on two systems—one for fire only and a second capable of meeting the combined demands of fire and general service. Although such estimates could be made by commissions and larger cities, with the aid of rate specialists, it appears that most determinations have been made without such analyses. The methods employed are discussed in various articles (*3, 7, 16–20*).

An alternative approach to the fire protection charge involves the assumption that *storage* may be provided *in lieu of capacity*. Such stored water may be assumed to be located in ground storage convenient to the mercantile or industrial areas and in controlled elevated storage to serve the periphery of the city. The assumptions, of course, are made solely to provide an alternative basis of computation and not to suggest that water

systems, in general, may find it either practical or desirable to substitute storage for pumping facilities and main capacities to meet the maximum demand for both fire and normal use.

If fire protection is to be charged with storage instead of capacity, the amount of storage to be assumed is shown in Table 5. To the expense of providing the necessary storage must be added the difference in cost between the mains required for general service and the larger ones required to deliver the water stored for fire protection to the hydrants. It may be reasonable to

TABLE 5

*Fire Storage**

Population	Flow Rate *gpm*	Duration of Pumpage *hr*	Total Storage Required† *mil gal*
5,000	2,250	9	1.2
10,000	3,000	10	1.8
40,000	6,000	10	3.6
100,000	9,000	10	5.4
200,000	12,000	10	7.2

* Based on NBFU requirements.
† Flow rate multiplied by duration.

assume that, if there were no need to provide water for fire protection, the secondary mains in general service could be smaller than the 6-in. mains which are now considered the minimum for areas to be "protected." On this basis, it would be logical to charge to fire protection the cost of a 4-in. differential in size applied to all the mains in the distribution system.

Applying this suggested basis for computing the fire charge—using the distribution of capital and expense in a city of 100,000, as presented in the tables in Section 2—the costs would be:

Hydrants and connections	
Fixed charges—6 per cent of $354,500 (Table 1)	$21,270
Operation and maintenance (Table 2)	5,380
Cost of water—1 per cent of total revenue (Table 4)	7,630
Storage and mains	
5.4 mil gal at 10 cents per gallon* —6 per cent of $540,000	32,400
Additional main costs†—6 per cent of $675,000	40,500
Total	$107,180

* Based on a combination of elevated and surface storage with pumps.
† Based on a differential of $0.75 per foot on 900,000 ft of distribution pipe.

The total of $107,180 is 14 per cent of the gross revenue of $763,000, approximately 21 per cent of the total annual fixed charges of $504,000, or $1.07 per capita per year.

If this basis of computation, using the same per capita units for both fixed and operating costs, were applied to cities of various sizes, the approximate per capita charges for fire protection would be as follows:

Population	Annual Charge *$/capita*
10,000	1.83
40,000	1.28
100,000	1.07
200,000	0.96
400,000	0.93
1,000,000	0.72

Two additional aspects of the subject of fire protection charges should be mentioned. These are taxes and corrections for deficiencies.

Taxes. It has been argued that the collection of a fire protection charge should obligate the water works to pay local taxes. In the preceding illustration, if local taxes are assumed at 1½ per cent on the capital investment, the amount of the tax would be approximately $126,000 annually, or approxi-

mately 18 per cent in excess of the fire charge.

Approximate figures, on the above basis of computation, indicate that taxes and the fire charge would be almost equal in a city with a population of 40,000; in smaller towns, taxes would be less than the fire charge; and, in larger, taxes would exceed the fire charge. This comparison provides some justification for the conclusion, not infrequently expressed, that offsetting the fire charge against local taxes is often a reasonable procedure.

Correction for deficiencies. The usual computation of a fire protection charge is based on the premise that the plant is capable of meeting both the general service and the fire demand simultaneously and adequately. This is frequently not the fact, however.

It has been proposed (*21*; *7*, page 232) that the fire charge should be reduced in proportion to the plant deficiency, based on the NBFU standard grading schedule (*22*). In this schedule, 32 items of water supply deficiency are considered. The maximum number of deficiency points assignable to the water system is 1,700, out of a possible total of 5,000 for all factors. A first-class city is one with no more than 500 points of deficiency, which may be distributed among water supply, fire department, fire alarm, police, building laws, fire prevention, and structural and climatic conditions. Many of these deficiencies may be corrected without material capital expenditures.

There is certainly no simple relationship between the number of deficiency points and the percentage by which the fire charge should be reduced on that account. In a deficient plant, an adequate supply for fire may be obtained with pumpers at hydrant pressures as low as 5 psi. It is recognized, of course, that excessively low hydrant pressures are a health menace, but it remains a fact that considerable water for fire will be obtained by pumpers regardless of the health aspects of low pressures. The standard requirement of the underwriters is "a minimum water pressure, during flow, of 20 [psi] . . . , except that a minimum of 10 [psi] is permissible" under certain conditions relating to hydrant size and distribution. At such pressures, the general service suffers, but the fire service receives its requirements in whole or in part; hence, there is logic in the contention that the proportion of plant capacity chargeable to fire is increased rather than decreased when the plant is deficient. Because of the complexity of the problem, any reductions in the fire protection charge should be based on an analysis by experts working with the underwriters.

Alternative methods of collecting fire charge. It has usually been assumed that a fire charge is an item of the tax budget and therefore collectible on the basis of total assessed valuations. Obviously, there is a considerable inequity in such a method. Vacant property pays for fire protection, although there is no fire hazard. Assessments made on the basis of structures only would be more equitable, but customers with high-cost, fireproof buildings would pay a greater amount for protection than others with less substantially constructed buildings of equal size which are of less value and may constitute greater fire hazards.

Another method would be to collect the fire charge with the water bill, in one of several ways. The first might be a charge, as above, based on the

assessed valuations of the structures of the customers. Instead, the charge might be made proportional to the product of the assessed valuation of the structure and the applicable insurance rate of the underwriters. Such a basis would entail considerable statistical work at the outset, even if the data were readily available. With the record once set up, however, it might not be too difficult to maintain. Certainly this plan would provide a more equitable distribution of the fire charge than the first method.

A simpler and more generally used method is to include the fire charge in the commodity rates or make it a part of the demand charge. If it is included in the commodity rates, the larger users of water will pay more in proportion to their protection than the smaller users, and much of the burden may fall on the so-called wet industries. If the charge is collected as a demand charge, based on meter sizes, a large part of the burden would be borne by the mass of domestic customers. It should be possible, however, to adjust the distribution of the demand charge to eliminate the obvious inequities. Using the previously mentioned city of 100,000 population as an example, Table 6 illustrates a distribution of the fire charge on the basis of group ratios of meters, as proposed in Section 4 for the distribution of customer demand charges (page 24).

Sprinkling, Air Conditioning, and Refrigeration

After allocations of capital and operating expenses have been made to the fire protection service, attention is given to the remaining special users whose requirements call for considerable plant. The most common of these special uses are sprinkling and air conditioning. In areas with warm, dry summers both types of use may be of consequence. In hot, humid areas, only air conditioning may be a problem, while, in cool, arid sections, sprinkling may result in a sizable water demand but air conditioning may be unimportant.

Although sprinkling may be an item of consequence for several hours of the day in some areas, it frequently causes a sharp afternoon or early-evening peak that places an added, short-term demand on all facilities. Generally, however, this peak may be substantially equalized by elevated storage or repumped surface storage. If so equalized, this portion of the additional demand mainly affects the distribution system between the storage and the customers' services. If the peak hour use is not equalized, the sprinkling demand requires additional capacity in both production and distribution facilities.

If a utility serves an entirely residential area, there is no need to make an allocation against sprinkling, because it is reasonable to assume that all customers sprinkle. Where, however, there is a sizable commercial and industrial load, much of which may be of the high load factor type, any extraordinary demand, such as that due to sprinkling, should assume a proper share of the additional expense. In other words, where sprinkling is an important factor in fixing plant capacity to meet the demands of the maximum day, it may be desirable to distribute the additional cost among the users of the sprinkling privilege. This may be accomplished by a suitable de-

mand charge, with the water used billed at the normal water rates.

Air conditioning and refrigeration differ from sprinkling in that the maximum demand usually lasts 10 hr or more on many consecutive days, and may not be handled practically with distribution storage. Air conditioning may start at 7:00 AM and continue until 5:00 PM for stores and offices. Restaurants will use water for longer periods, and particularly in the evenings. Home and hotel air conditioning may also continue for longer periods. These last three types are comparatively new water uses, which occur during the hours when sprinkling has historically placed its heavy loads upon water systems.

Here again, in areas where the air-conditioning and refrigeration load becomes an important factor in fixing plant capacity to meet the demands during the maximum day, the additional fixed charges may be assessed against users of the service, as an additional demand charge, measured or estimated, in gallons per minute of maximum demand; and the water used may be billed at the normal commodity rates. Alternatively, the entire cost of this service may be collected through an air-conditioning and refrigeration commodity rate.

Application. To make precise applications of the demand charges for sprinkling and air conditioning and refrigeration requires data based on system load records, separating the daily load curve of the maximum day into its component normal and special demands. The allocation of property to special uses, however, necessitates information not readily available, and the development of principles of application not as yet well defined.

For the purposes of this report, an oversimplified computation is illustrated, based on the pumpage record of the city referred to in Section 2. This record showed the following rates of pumpage on Jun. 12, 1952, the

TABLE 6

Distribution of Fire Charge by Meter Group Ratios

Meter Size in.	No. of Meters	Group Ratio	Equivalent No. of ¾-in. Meters	Annual Charge	
				Per Meter* $	Total $
⅝	23,586	1	23,586	2.25*	53,068.50
¾	909	2	1,818	4.50	4,090.50
1	772	4	3,088	9.00	6,948.80
1½	166	10	1,660	22.50	3,735.00
2	201	25	5,025	56.25	11,306.25
3	96	45	4,320	101.25	9,620.00
4	66	90	5,940	202.50	13,360.00
6	10	170	1,700	382.50	3,825.00
8	1	300	300	675.00	675.00
	Total		47,437		106,629.05

* The charge for a ¾-in. meter is obtained by dividing fire service cost ($107,000) by total number of equivalent ¾-in. meters (47,437). For larger sizes, the ¾-in. charge ($2.25) is multiplied by the corresponding group ratio.

maximum day (normal and special rates of use are estimated):

Item		Rate *mgd*
Max. day		34.1
Max. hour (7 PM–8 PM)		54.4
Day rate (9:30 AM–4:30 PM)		
Sprinkling	10	
Air conditioning	12	
Other uses	23	
Total day rate		45.0

In this instance, the maximum hour was not equalized by storage. It could have been equalized with approximately 1 mil gal of available or controlled storage, at an annual cost of approximately 6 per cent of $100,000 or $6,000.

Based on the above record, plant may be allocated to the several uses in accordance with the proportion of the rate for each use relative to the total rate of use during the hours from 9:30 AM to 4:30 PM (the ratio of sprinkling to total use is 10:45, or 22.3 per cent; for air conditioning, the ratio is 12:45, or 26.7 per cent). The assumption is made that the hourly peak is equalized by storage, and the cost of the storage is charged to the use producing the peak (assumed, in this instance, to be sprinkling).

In Table 7, the percentages given in the preceding paragraph are applied to the fixed charges shown in Table 4 (page 10), less the fixed charges allocable to fire protection (see page 16). The fixed charges on peak storage are allocated to sprinkling.

Demand charge for sprinkling. The total of $84,800 per year allocated to sprinkling in Table 7 corresponds to a charge of approximately $3.50 per year for 24,500 ⅝-in. and ¾-in. meters. This charge may be added to the demand charge developed in Section 4 for normal users (see Table 14, page 30).

TABLE 7

Allocation of Fixed Charges to Sprinkling and Air Conditioning

Item	Total Annual Charges $	Fire $	Balance $	Sprinkling (22.3%) $	Air Conditioning (26.7%) $
Production	198,480	32,400	166,080	37,000	44,300
Distribution	227,850	40,500	187,350	41,800	50,000
Storage	6,000		6,000	6,000	
Total	432,330	72,900	359,430	84,800	94,300

Demand charge for air conditioning. The air-conditioning total of $94,300 per year, if allocated to the 8,000 tons of nonconserved air-conditioning and refrigeration equipment now installed in the city under discussion, corresponds to a charge of approximately $12 per year per rated ton. This would be a surcharge, with all water used being charged at the regular water rate schedule.

It is of interest to note that, in an order dated Jul. 1, 1952, the Arkansas Public Service Commission approved "a monthly demand charge of $2.50 per rated ton of capacity on customers using water in connection with air-

conditioning units having a rated capacity of 3 tons or more without recirculatory cooling equipment, for the months of May, June, July, August, and September of each year." This amounts to $12.50 per ton per year.

Other Special Users

In many utilities, there will be other customers with load patterns that call for special analysis. These customers may be other utilities that purchase water in large quantities but have the load characteristics of domestic users rather than large industrial users. There may be a large component of sprinkling and air conditioning in such a demand. Also golf clubs, greenhouses, truck gardeners, swimming pools, and similar users may impose large summer peak loads, which may need to be analyzed separately, or as another special use group, so that their water rates may be properly established. In some places, too, one, or a few, industries may take a large part of the plant output. Studies of their specific loads will be necessary to prevent either subsidization of, or discrimination against, such large users.

Section 4—Rate Schedules for Normal Users

In Section 3, the customers of a water system were classified as normal and special users, and it was proposed that those portions of the fixed charges arising from the plant specifically required to meet the demands of the special users be allocated to them on the basis of their individual demands. This section discusses the methods of formulating rate schedules through which the balance of the fixed charges and all operation and maintenance expense may be distributed among *all* customers, as nearly as possible in proportion to the cost of supplying the commodity.

Costs have been classified in Section 2 in two ways: into customer, capacity, and commodity costs; and into the *functional* costs involved in production, distribution, customers' commercial expense, customers' services and meters, and hydrants and connections. The development of rate schedules, using these cost classifications, is discussed below under the demand (or capacity) basis and under the functional cost basis.

Demand Basis Service Charge

Two of the problems involved in the demand basis are the determination of the amount of the demand or capacity costs distributed as a service charge (discussed in Section 2) and the distribution of this portion of the costs to customers.

A basis for determing the amount of the capacity or demand charge proposed in Section 2 is that the charge be limited to a portion only of the remaining fixed costs, after suitable deductions have been made for fire protection, customers' investment, and property devoted to special uses. In order to arrive at an acceptable portion of fixed costs chargeable to capacity or demand, certain assumptions must be made for the sake of reasonable equity.

1. Total Demand Costs

The total of the so-called demand costs may be assumed to be limited to 50 per cent of the capital costs of depreciation, taxes, and return on the

investment of that part of the plant devoted to normal uses, the balance of the capital costs being charged to the commodity.

Capital costs are as much a part of the cost of production as labor, fuel, electricity, and other operation and maintenance expense. No business produces goods without capital costs. Therefore, some part of depreciation, taxes, and interest should be included in the cost of the commodity. If all customers used water at a uniform rate, plant size would need to be just equal to the sum of their requirements. Owing to variations in the rates of demand, however, the plant must be made larger than that necessary to supply the average load. Excluding special uses, it is not uncommon to experience an average daytime delivery rate on the maximum day of approximately twice the average annual rate. Under such conditions, half of the capital costs would appear to be chargeable to the commodity and the other half to demand. If the average daytime delivery rate on the maximum day, for normal use, were greater or less than twice the average annual rate, modifications in the 50–50 division would be warranted.

Possibly further justification for a 50–50 arbitrary division of capital costs is found in a recent supreme court case (*23*) which "sustained the Federal Power Commission in allocating return and income taxes, 50 per cent to volume and 50 per cent to demand." The court ruled that "a treatment of transmission costs by which 50 per cent of the return is assigned to capacity costs and 50 per cent to volumetric costs is proper, as against the contention that the entire return should be apportioned to capacity costs."

2. Equitable Distribution

The second problem in applying the demand basis has been to find a method for the equitable distribution of demand costs between users. The theory that has been followed involves the distribution of such costs in accordance with the relative capacities of the individual meters. But relative capacities of meters vary with the manufacturer, the type of meter, and the difference in permissible pressure loss. In actual application, the distribution of costs in this manner has often resulted in the collection of most of the demand costs from the domestic customers, who constitute the great bulk of the water users and are served largely by ⅝-in. meters.

In the city used for illustration in this report, the application of commonly employed capacity ratios will show that the 23,586 ⅝-in. meters, constituting 90 per cent of the total, would register approximately 37 per cent of the entire plant output and would bear about 75 per cent of the total demand charge. Another striking illustration is provided by a city where the transfer of 64 per cent of the total revenue (an amount computed to represent the "ready-to-serve" costs, as usually defined) from the commodity charge to the demand charge more than doubled the average charge for service through the ⅝-in. meter and reduced the average charge through a 12-in. meter to less than one-third (*3*).

One argument for such a transfer of burden from industrial to domestic customers has appeared in the literature since the early days of the rate controversy. Large allocations to the service charge have been made on the theory that one purpose of such a charge, which is independent of the

meter record, is to "stabilize" income. "If, due to the ups and downs of prosperity," too much dependence is put on the commodity charge, "the revenue will at times become inadequate" (*24*). In cities where a large proportion of the output is sold to industries, business depressions or long strikes may seriously reduce revenue unless some of the loss in water sales is recouped through a substantial demand charge. Another objective of the larger demand charge has been to make possible a "promotional" commodity rate—sometimes referred to as a rate based on incremental costs—that will enable a water works to justify sales to "a larger consumer . . . at any rate which will add to the net revenue of the plant, even though the rate is below the average cost as built up by administration, operating, depreciation, interest, and profit" (*24*). Such promotional rates have been used in the past to subsidize new industries or to retain a customer who might otherwise seek a separate source of supply. However convincing such premises may appear in particular instances, their adoption as a general basis would be contrary to the assumption that rate structures should, insofar as practicable, distribute all costs to customers on the basis of the expense of supplying the commodity and rendering service.

The difficulty of loss of revenue during depressions can be partially overcome by an adequate schedule of minimum charges for each size of meter. Such a minimum schedule is presented later in this report.

As for the inequities arising out of the use of the capacity ratios of individual meters, it has been suggested recently that the development and application of a demand meter would afford a solution. The momentary maximum demand of any single dwelling, however, is not a measure of that particular customer's effect on plant capacity. The actual maximum demand on a water system never equals the total combined potential demand of all users. If all meters in Detroit, for example, made a simultaneous demand equal to the sum of their individual capacities, at 5 psi loss, the total demand on the system would approximate five times the actual system capacity. Obviously, the water system is designed to meet no such theoretical total demand but rather the actual combined rates of use by all customers at a time of maximum demand. To obtain such a record from all customers would be impracticable. The usefulness of maximum-demand meters will probably be confined, therefore, to *entire* residential areas, special users, large industries, and suburban communities.

Demand costs may, however, be distributed on the basis of ratios that reflect the maximum demands of meters in *groups* of sizes rather than the capacity ratios of individual meters. Such a basis would aim at taking into account the diversity between customer groups and between customers within specific groups. For instance, all domestic customers will not require water at the maximum rate simultaneously. This diversity is normally larger within larger groups. It will probably be largest in the domestic customer group, less in the commercial, and still less in the industrial.

The data upon which to base such group ratios are generally lacking, but certain assumptions may be made as a basis for approximate ratios. It may

be assumed that the maximum simultaneous demand of all the meters in a residential area could be six times the average rate of use; that the maximum demand of large meters serving an industrial area would be nearer twice the average rate of use; and that meters of intermediate size can be given intermediate ratios. The ratio used for, say, the residential group of meters, when applied to the total of such sizes of meters, should yield a result in "demand on the plant" equal to the total actual residential demand. Likewise, the ratios of all groups, when applied to all meters, should result in a "total maximum demand" equal to the total plant capacity available for normal users.

Table 8 shows the effect of such assumptions, applied to data for Detroit. The group ratios are compared with the individual capacity ratios for meters of the disk and current types.

3. Other Service Costs

In addition to the demand costs which it is proposed to distribute among all customers on the basis of the meter group ratios, three other classes of costs should be included in a service charge:

a. All accounting, meter-reading, billing, collecting, and bookkeeping costs and a share of the general and administrative costs may be distributed equally among all customers.

TABLE 8

Meter Group and Individual Capacity Ratios

Meter Size *in.*	Avg 3-Month Consumption* *cu ft*	Multiplier	Maximum Rate *cu ft*	Group Ratios		Individual Capacity Ratios†	
				Computed	Rounded	Disk Meters	Current Meters
⅝	2,406	6	14,436	1	1	1	
¾	4,415	6	26,490	1.84	2	1.5	
1	11,369	5.5	62,530	4.33	4	2.8	
1½	25,591	5.5	140,740	9.8	10	4.3	7.5
2	70,802	5.0	354,060	24.6	25	8.7	12.3
3	167,333	4.0	669,332	46.3	45	13.2	25.4
4	521,558	2.5	1,303,895	90.5	90	19.5	36.0
6	1,232,684	2	2,465,368	171	170	34.5	70.0
8	2,238,557	2	4,477,154	310	300		135.0
10	3,644,078	2	7,288,156	505	500		173.0
12	8,170,500	1.75	14,298,375	993	1,000		187.0

* Detroit data (*1*).
† Based on data from a well known manufacturer.

b. All other customer costs, both capital and operation and maintenance, chargeable to meters and services, may be distributed to meters on the basis of plant records or, lacking such records, on ratios that represent approximately the installation costs of the meters and services.

c. Sprinkling costs, as developed in Table 7, may be distributed to ⅝-, ¾-, and 1-in. meters on the basis of their group capacity ratios.

Demand Basis Commodity Rates

The demand, accounting, and customer costs having been distributed through a service charge, the remaining costs are charged and collected through commodity rates. The standard form of rate schedule adopted by AWWA on May 24, 1923, suggested either three or four "slides" and fixed the quantity of water to be delivered in each slide, but the unit prices were left to be determined, with the qualification "that the ratio between the first and third rate should be limited to about 2 to 1, . . . and the amount of slide between the first and fourth rates should not exceed the ratio of 3 to 1" (*5*, page 460). This general plan is

TABLE 9

*Distribution of Annual Costs**

1	2	3	4	5	6	7	8
Item	Totals $	Fire $	Sprinkling $	Air Conditioning $	Balance to Other Services $	Balance Divided Between	
						Service Charge (50%) $	Commodity Rates (50%) $
Capital Costs							
Production	198,480	32,400	37,000	44,300	84,780	42,390	42,390
Distribution	233,850	40,500	47,800	50,000	95,550	47,775	47,775
Customers' meters and services	50,400				50,400	50,400	
Hydrants	21,270	21,270					
Subtotal	504,000	94,170	84,800	94,300	230,730	140,565	90,165
Operation and Maintenance Costs							
Production	159,660	7,630			152,030		152,030
Distribution	30,640				30,640		30,640
Customers							
Commercial	50,540				50,540	50,540	
Meters and services	12,780				12,780	12,780	
Hydrants	5,380	5,380					
Subtotal	259,000	13,010	0	0	245,990	63,320	182,670
Total	763,000	107,180	84,800	94,300	476,720	203,885†	272,835‡
Per cent of total	100	14.1	11.1	12.3		26.7	35.8

* Figures in Column 2 taken from Table 4 (page 10); in Column 3, from page 16; in Columns 4 and 5, from Table 7 (page 20).

† Comprising: demand charge, $90,165; commercial expense, $50,540; and meters and services, $63,180.

‡ Redistributed on the basis of meter readings.

adhered to in the application that follows.

Application of Demand Basis

Based on the costs in Table 4 (page 10) and the allocation to fire (page 16), sprinkling, and air conditioning and refrigeration (Table 7, page 20), Table 9 illustrates a distribution of costs to the special uses and to the service charge, only about 24 per cent of the total costs would be collected through commodity rates, while, if all demand costs were allocated to commodity rates, approximately 54 per cent of the total costs would be collected on the basis of meter readings. The latter allocation approximates the distribution discussed under "Functional Cost Basis" (page 27), in which the service charge includes only customer costs from commercial expense and meters and services, and does not include demand costs.

TABLE 10

Distribution of Service Charges

1	2	3	4	5	6	7	8	9	10	11
Meter Size in.	No. of Meters	Commercial Expense*		Demand†			Meters and Services‡			Total Quarterly Service Charge $
		Ratio	Quarterly Charge per Meter $	Ratio	Equivalent No. of ¾-in. Meters	Quarterly Charge per Meter $	Ratio	Equivalent No. of ¾-in. Meters	Quarterly Charge per Meter $	
¾	23,586	1	0.50	1	23,586	0.50	1	23,586	0.50	1.50
1	909	1	0.50	2	1,818	1.00	1.5	1,364	0.75	2.25
1½	772	1	0.50	4	3,088	2.00	2.25	1,737	1.10	3.90
2	166	1	0.50	10	1,660	5.00	4.0	664	2.00	7.50
3	201	1	0.50	25	5,025	12.50	6.0	1,206	3.00	16.00
4	96	1	0.50	45	4,320	22.50	10.0	960	5.00	28.00
6	66	1	0.50	90	5,940	45.00	20.0	1,320	10.00	56.00
8	10	1	0.50	170	1,700	85.00	35.0	350	17.50	103.00
	1	1	0.50	300	300	150.00	50.0	50	25.00	175.00
	25,807				47,437			31,237		

* Commercial expense ($50,540) divided by total meters (25,807) equals $1.96 per year, or approximately $0.50 per quarter, per meter.

† Demand ($90,165) divided by total equivalent ¾-in. meters (47,437) equals $1.91 per year, or approximately $0.50 per quarter, per equivalent ¾-in. meter.

‡ Meters and services ($63,180) divided by total equivalent ¾-in. meters (31,237) equals $2.02 per year, or approximately $0.50 per quarter, per equivalent ¾-in. meter.

service charge and commodity rates, in the detail needed to compute a rate structure.

This distribution is premised on the allocation of demand costs equally between the service charge and the commodity rates. Even so, only about 36 per cent of the total costs is collected on the basis of meter readings. If all demand costs were to be included in

Service Charge Distribution

The distribution of the service charge of $203,885 (Column 7 of Table 9) is presented in Table 10. Commercial expense amounts to $50,-

540; the demand charge covers capital costs of $42,390 from production and $47,775 from distribution, a total of $90,165; and the charge against meters and services includes a capital charge of $50,400 plus an operation and maintenance cost of $12,780, making a total of $63,180.

The distribution of the sprinkling charge of $84,800 (Column 4, Table 9) among the ⅝-, ¾-, and 1-in. meters, on the same basis as is used in Column 7 of Table 10 to distribute the demand charges, would result in charges of $3.00 per year for the equivalent of 28,942 ⅝-in. meters. The sprinkling charges to be added to Column 11 of Table 10 would then be $0.75 per quarter for ⅝-in. meters, $1.50 for ¾-in., and $3.00 for 1-in. meters (see Table 14, page 30).

Computation of Commodity Rates

In compliance with the form of rate schedule outlined in the *Manual of Water Works Practice* (*5*), the unit rates applicable to wholesale, intermediate, and domestic customers may be derived from the costs in Column 8 of Table 9, taken together with the production and sales records of the particular community.

To determine the wholesale rate, add the capital costs of production ($42,390) to the operation and maintenance costs of production ($152,030). Divide this total ($194,420) by the total annual output (in this instance, 4,530 mil gal), to obtain a figure of 4.3 cents per 1,000 gal.

The average cost of distributing water may be determined as follows: from Column 8 of Table 9, the total distribution costs are $78,415; divide this total by the sales to all intermediate and domestic customers (estimated at 2,580 mil gal per year) to obtain a figure of approximately 3 cents per 1,000 gal. The average rate to these customers would then be 7.3 cents per 1,000 gal.

The following unit rates would produce slightly more than the total desired revenue of $272,835 (Column 8, Table 9):

Class	Quantity *mil gal*	Rate *¢/1,000 gal*	Revenue *$*
Wholesale	1,950	4.3	83,850
Intermediate	910	5.8	52,780
Domestic	1,670	8.2	136,940
Total	4,530		273,570

A minimum charge can be worked out as illustrated in Table 13 (page 29).

Functional Cost Basis

The functional cost basis was advocated in 1948 by the Committee on Water Rates of the Michigan Section (*1*). It is not new in theory, but is a reversion to the basis adopted in 1923 by an AWWA rate committee under the chairmanship of Allen Hazen (*6*) and is in accord with a recommendation of a similar committee of the New England Water Works Assn. (*25*). It consists of a service charge, based on the size of the meter, including only customer costs (commercial expense plus meters and services *), with all so-called demand costs * collected through the commodity rates. As recommended in the *Manual of Water Works Practice* (*5*), the commodity charge is applied in three steps—through wholesale, intermediate, and domestic rates.

* See footnotes to Table 10.

This basis is applicable to the average community and to the average customer using year-round service in a normal manner. It does not provide for special users making intermittent or abnormal demands on the water system. It is premised on the theory that a more substantial equity will be achieved between normal users by collecting the fixed charges on the basis of the meter reading rather than arbitrarily on the basis of the size of the meter as a measure of the hypothetical demand of the customer. It avoids the problems involved in the separation of total costs into demand and commodity costs and their redistribution to customers.

TABLE 11

Service Charge on Functional Cost Basis

Meter Size in.	Quarterly Charge per Meter		
	Commercial Expense* $	Meters and Services† $	Total $
⅝	0.50	0.50	1.00
¾	0.50	0.75	1.25
1	0.50	1.10	1.60
1½	0.50	2.00	2.50
2	0.50	3.00	3.50
3	0.50	5.00	5.50
4	0.50	10.00	10.50
6	0.50	17.50	18.00
8	0.50	25.00	25.50

* From Table 10, Column 4.
† From Table 10, Column 10.

The rules for the application of this method, substantially as proposed by the Michigan Section Committee, are as follows:

Meter Service Charge

The meter service charge is to include:

1. All commercial expense and a suitable portion of administrative and overhead costs, the total of which is to be divided *equally* among all accounts. This apportionment should, however, reflect any known variations in cost, such as arise from variations in the frequency of meter readings.

2. All expense arising out of meters and services, with a share of administrative expense and overhead, the total of which may be distributed among accounts on the basis of the *meter* cost.

3. A charge for water sufficient to make a minimum bill, based on the commodity rates and reasonable minimum quantities for each size of meter. Such minimum bills will tend to control the size of meters and maintain the minimum necessary revenue through periods of fluctuating demands for water.

Commodity Unit Rates

1. The *wholesale unit rate* is obtained by dividing the total of all production and transmission expense (capital costs plus all operation and maintenance) by the total annual sales of water. Transmission mains are defined as those which convey water to the distribution system and are generally without service taps.

2. The *intermediate unit rate* is obtained by adding the intermediate increment to the wholesale rate. The intermediate increment is obtained by dividing the total expense arising out of distribution mains larger than 6 in. by the water sold through all meters, except sales at the wholesale rate.

3. The *domestic unit rate* is obtained by adding the domestic increment to the intermediate rate. The domestic increment is obtained by dividing the total expense arising out of mains 6 in.

and smaller by the water sold through all meters ¾ in. and smaller.

Application of Functional Cost Basis

Computation of service charge. Based on the costs in Column 7 of Table 9, the amounts to be collected through the service charge are: commercial expense, $50,540; plus meters and services ($50,400 plus $12,780), $63,180; total, $113,720. These amounts were distributed by meter sizes in Table 10 and are as shown in Table 11.

TABLE 12

Step Quantity Limitations (Applied to Detroit Data)

Rate Step	Max. per Quarter	
	cu ft	*gal*
Michigan Section Basis		
Domestic	8,830	66,000
Intermediate*	141,600	1,060,000
Manual (5) Basis		
Domestic	10,000	75,000
Intermediate	90,000	675,000

* Including 2-in. meters.

Computation of commodity rates. The commodity rates may be computed as follows:

The *wholesale rate* is obtained by adding the capital and operation and maintenance costs of production (Table 9, Column 6) and dividing this total by the total annual sales: ($84,780 + $152,030) ÷ 4,530 mil gal = 5.25 cents per 1,000 gal.

The *intermediate increment* is obtained by taking one-half the total distribution costs (Table 9, Column 6) and dividing by the total annual sales except sales at the wholesale rate (the nonwholesale figure is estimated at 57 per cent of the total): ½($95,550 + $30,640) ÷ 2,580 mil gal = 2.44 cents per 1,000 gal. Adding 2.44 to 5.25 gives 7.7 cents as the intermediate rate.

The *domestic increment* is obtained by taking one-half the total distribution costs (as above) and dividing by 1,670 mil gal (sales at domestic rate, estimated at 37 per cent of total sales). The resulting increment is approximately 3.8 cents per 1,000 gal, so that the domestic rate is 11.5 cents per 1,000 gal.

TABLE 13

Minimum Bill

Meter Size *in.*	Min. Quantity per Quarter *gal*	Quarterly Charge *$*
¾	9,000	2.00
¾	18,000	3.30
1	36,000	5.75
1½	90,000	12.70
2	225,000	24.00
3	400,000	39.00
4	800,000	74.00
6	1,500,000	118.00
8	2,700,000	189.00

These unit rates would produce slightly more than the $363,000 required to meet the costs in Column 6 of Table 9 ($476,720 total annual costs less $113,720 customer charges):

Class	Quantity *mil gal*	Rate *¢/1,000 gal*	Revenue *$*
Wholesale	1,950	5.25	102,375
Intermediate	910	7.7	70,070
Domestic	1,670	11.5	192,050
Total	4,530		364,495

TABLE 14

Comparison of Schedules

Meter Size *in.*	Demand Basis		Functional Cost Basis	
	Service Charge* $	Sprinkling Charge $	Service Charge† $	Sprinkling Charge $
⅝	1.50	0.75	1.00	0.75
¾	2.25	1.50	1.25	1.50
1	3.90	3.00	1.60	3.00
1½	7.50		2.50	
2	16.00		3.50	
3	28.00		5.50	
4	56.00		10.50	
6	103.00		18.00	
8	175.00		25.50	
Water Use—*gal*	Commodity Rates—*cents per 1,000 gal*			
First 75,000	8.2		11.5	
Next 675,000	5.8		7.7	
Over 750,000	4.3		5.25	

* From Table 10.
† From Table 11.

Step Quantity Limitations

With regard to step quantity limitations, the Michigan Section committee report (*1*) suggested that, "as an initial determination . . . , the domestic rate apply up to a quantity equal to twice the average consumption through all domestic meters, ¾ in. and ⅝ in.; that the intermediate rate apply up to a quantity equal to twice the average consumption through all intermediate meters; and that all quantities over the intermediate limit fall under the wholesale rate." Table 12 compares the effect of these limitations and the ones recommended in the *Manual of Water*

TABLE 15

Average Quarterly Bills (Using Detroit Data)

Meter Size *in.*	Avg Quarterly Sales per Meter *gal*	Demand Basis		Functional Cost Basis	
		Quarterly Bill $	Price per 1,000 gal *cents*	Quarterly Bill $	Price per 1,000 gal *cents*
⅝	18,000	3.73	20.7	3.82	21.2
¾	33,000	6.46	19.6	6.54	19.8
1	85,000	13.63	16.0	14.00	16.5
1½	190,000	20.32	10.7	19.99	10.5
2	530,000	49.15	9.3	47.17	8.9
3	1,250,000	94.85	7.6	92.36	7.4
4	3,900,000	236.80	6.1	236.49	6.1
6	9,250,000	513.85	5.5	524.86	5.7
8	16,700,000	906.20	5.4	923.49	5.5

Works Practice (5, page 462), using Detroit as an example.

Minimum Bills

The service charge plus the commodity rate on the functional cost basis may result in too low a bill to minimum users. Consequently, it is proposed that minimum bills be based on quantities for each size of meter, starting at 100 gpd for a ⅝-in. meter and increasing for the larger sizes in proportion to the group capacity ratios (page 24). Using the previously computed unit rates of 11.5, 7.7, and 5.25 cents per 1,000 gal and the *Manual of Water Works Practice* step limitations, the minimum bills, in round figures, would be as shown in Table 13.

Comparisons of Schedules

Schedules computed on the demand and functional cost bases are compared in Table 14. If these schedules were applied to the average quantities of water sold in Detroit through each size of meter, the average quarterly bills, including sprinkling, would correspond very closely, as shown in Table 15.

Other Alternatives

Omission of service charge. The rates previously described, whether on the demand or functional cost basis, contemplate a service charge, together with commodity rates in three steps and, if desired, minimum bills for each size of meter. Many cities, however, preferring to avoid a service charge, simplify their rate structure by employing a single minimum charge under which a minimum quantity of water is furnished, followed by the usual stepped rates. This minimum charge should be in an amount sufficient to provide the service charge plus the cost of the water furnished under the minimum charge.

Based on data previously presented, Table 16 shows how a rate structure of this type is computed. Obviously, such a rate structure must be checked against the sales records for each size of meter in order to be sure of the gross revenue. Using the approximate data available in this instance, the income is estimated as shown in Table 16. The totals of $563,600 (demand basis) and $564,400 (functional cost basis) may be compared with the figures in Table 9, which indicates a total annual cost (including sprinkling but excluding fire and air conditioning) of $561,520.

Rate to include all special uses. If, to the above rate structure, which provides for the normal service charges plus sprinkling in the minimum charge, there is added the fire charge of $107,180 (Table 9, Column 3), as well as the $94,300 in fixed charges arising out of air conditioning and refrigeration (Table 9, Column 5), the total is increased by $201,480. All of these special-use costs may be collected in the minimum charge, covering 0–9,000 gal per quarter, or else some part of them may be spread over the other steps in the schedule. If the entire amount is collected in the minimum charge—that is, apportioned equally among all meters—then the sum of $201,500 is divided by 25,807 meters, and the minimum charges are increased by $7.80 per year. The result is a minimum charge of $13.60 plus $7.80, or $21.40 per year ($5.35 per quarter), on the demand basis; and $11.10 plus $7.80, or $18.90 per year ($4.73 per quarter), on the functional cost basis. The succeeding rate steps remain the same as in Table 16. The gross revenue from such a rate, applied to the sales records, should ap-

TABLE 16

Omission of Service Charge

Item	Demand Basis	Functional Cost Basis
Computation of Charges		
*Service charge**		
Commercial expense	$50,540	$50,540
Demand charge	90,165	
Meters and services	63,180	63,180
Subtotal	$203,885	$113,720
Sprinkling charge†	84,800	84,800
Cost of water furnished (760 mil gal)‡		
At 8.2¢ per 1,000 gal	62,320	
At 11.5¢ per 1,000 gal		87,400
Total charges	$351,005	$285,920
Average per meter (divide by 25,807)		
Per year	$13.60	$11.10
Per quarter	$ 3.40	$ 2.77
Rate Structure		
Water use per quarter		
First 9,000 gal	$3.40 per quarter	$2.77 per quarter
Next 66,000 gal	8.2¢ per 1,000 gal	11.5¢ per 1,000 gal
Next 675,000 gal	5.8¢ per 1,000 gal	7.7¢ per 1,000 gal
Over 750,000 gal	4.3¢ per 1,000 gal	5.25¢ per 1,000 gal

Estimated Income

	Rate	Income	Rate	Income
Water sales				
760,000,000 gal	$13.60§	$351,000	$11.10§	$286,500
960,000,000 gal	8.2¢	78,700	11.5¢	110,000
870,000,000 gal	5.8¢	50,500	7.7¢	67,000
1,940,000,000 gal	4.3¢	83,400	5.25¢	101,900
4,350,000,000 gal		$563,600		$564,400

* See Table 10, footnotes.
† See Table 9, Column 4.
‡ Estimated use through 25,807 meters.
§ Minimum charge per year.

proximate the total expense of $763,000 shown in Table 9, Column 2.

Four Bases for Rate Structures

This section has discussed and computed rates on four bases:

1. *A demand basis* for normal users (page 21), including a service charge for each size of meter and commodity rates in three steps. The service charges are to include: all commercial expense, all costs chargeable to meters and services, and a demand charge equal to 50 per cent of the fixed costs. All special uses are to be charged separately to customers.

2. *A functional cost basis* for normal users (page 27), differing from the demand basis only in that all fixed charges are included in the commodity rates; minimum bills are based on the sum of the service charge plus the use of 9,000 gal per quarter for each equivalent $\frac{5}{8}$-in. meter.

3. *Commodity rates only,* without a service charge, but substituting a *suitable minimum charge,* and with all special uses charged separately to customers (page 31).

4. *Commodity rates only,* without a service charge, but with a *minimum charge sufficient to provide all the costs of special uses* (page 31).

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AWWA C602-54T

American Water Works Association

Tentative

Standard Specifications

for

CEMENT-MORTAR LINING OF WATER PIPELINES IN PLACE— SIZES 16 INCHES AND OVER

The American Water Works Assn. has adopted and promulgated these "Specifications for Cement-Mortar Lining of Water Pipelines in Place—Sizes 16 Inches and Over." These specifications are based upon the best known experience and are intended for use under normal conditions. They are not designed for unqualified use under all conditions. The procedures outlined should be reviewed and accepted by the responsible engineer in charge of the operation before contracts are made for any such work.

Approved as "Tentative" May 27, 1954

Second Printing, December 1954

AMERICAN WATER WORKS ASSOCIATION
Incorporated
521 Fifth Avenue, New York 17, N.Y.

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Tentative Standard Specifications for

Cement-Mortar Lining of Water Pipelines in Place—Sizes 16 Inches and Over

Sec. 1—Scope

These specifications cover the requirements for the material and application of a cement-mortar lining to the inside surface of steel and cast-iron water pipelines, 16 in. and over in diameter, that have been previously installed. The application methods are: [1] cement-mortar lining of all straight pipe sections and long-radius bends by a machine which progresses uniformly through the pipe and projects cement-mortar against the pipe surfaces, obtaining a smooth lining of uniform thickness and with smooth transitions over joints; and [2] cement-mortar lining of sharp bends, specials, and areas closely adjacent to valves by handwork where machine placing is impossible.

Sec. 2—Definitions

Under these specifications, the following definitions will apply:

2.1. *Purchaser.* The word "purchaser" shall mean the person, firm, corporation, or governmental subdivision entering into a contract or agreement for the purchase of any material or any work, or both, to be performed under these specifications.

2.2. *Contractor.* The word "contractor" shall mean the person, firm, or corporation executing the contract or agreement with the purchaser to furnish any material or to perform any work, or both, under these specifications.

2.3. *Engineer.* The word "engineer" shall mean the engineer or inspector employed by the purchaser and acting as his representative; or their respective assistants, properly authorized and limited to the particular duties entrusted to them; or the purchaser himself, acting as his own engineer.

Sec. 3—General Requirements

The contractor shall furnish all labor, material, and equipment required; shall prepare all surfaces; and shall apply cement-mortar lining to the interior surfaces of the pipeline to be lined in accordance with these specifications.

Sec. 4—Supplemental Details to Be Supplied by Purchaser

Wherever these specifications are used as subsidiary specifications by the purchaser, he shall include a supplementary specific statement regarding:

4.1. *Project.* Diameter, length, and location of pipeline, including plan and profile drawings, accessible manholes, and all other details of the pipe within the scope of the contract.

4.2. *Thickness of cement-mortar lining.* Nominal thickness of cement-mortar lining required. (Table 1 is intended as a guide to the purchaser in selecting the desired thickness of cement-mortar lining.)

The purchaser should specify if the thickness of cover over rivet heads and

over lock-bar longitudinal seams of steel pipe is required to be other than $\frac{1}{8}$ in. as specified in Sec. 13.2.

4.3. *Services furnished by purchaser.* Description of all services furnished by purchaser, such as removal and replacement of line valves, operation of valves, shutting off of inflow of water from connecting pipelines, and temporary connections to consumers.

4.4. *Additional work to be performed by contractor.* Description of additional work to be performed by contractor, such as repairs to deteriorated steel pipe, excavation, backfill and repair work on deteriorated pipe is contemplated, the purchaser should include in his bid schedule, requests for a price for repairing each hole. When the repair work is more extensive than can be accomplished by the foregoing means, such repair work should be done by the purchaser at his own expense or should be performed by the contractor as required by the purchaser under the "extra work" provision of the contract.

4.5. *Water.* Supply and location of sources of water for cleaning and lining operations.

4.6. *Disposal of cleaning water.* Requirements for disposal of cleaning water.

TABLE 1

Recommended Minimum Thickness of Cement-Mortar Lining for Pipelines

Type of Pipe	Diameter of Pipe *in.*	Nominal Thickness of Lining* *in.*
Cast iron	16–24	$\frac{3}{16}$
	over 24	$\frac{1}{4}$
Steel	16–36	$\frac{1}{4}$
	over 36	$\frac{3}{8}$

* For badly deteriorated pipe, the purchaser should specify such greater thickness of lining as his engineering judgment indicates.

surfacing work for access holes, and opening and closing of access holes in the pipeline.

NOTE: Work in repairing deteriorated steel pipe is sometimes included as a part of the contract for cement-mortar lining of steel pipe. Repairs on steel pipe are made before cement-mortar lining is placed. Repairs on small holes in the steel pipe are made by means of soft wood plugs driven and cut flush with the interior surface of the pipe, or by means of drilling and tapping the pipe walls and inserting screwed cast-iron or steel plugs flush with the interior surface. When re-

Sec. 5—Material and Workmanship

All material furnished by the contractor must be of the quality specified. All work shall be done in a thorough and workmanlike manner by trained personnel under the supervision of experienced men skilled in the application of cement-mortar lining to pipelines in place.

Sec. 6—Equipment

The contractor's equipment for cleaning, applying cement-mortar, and curing shall be so designed and manufactured and in such condition as to permit the workmen to follow the procedure and obtain the results prescribed in these specifications.

Sec. 7—Samples of Cement-Mortar Linings

Bidders shall submit with their bids samples of cement-mortar lining, if requested by the purchaser in his supplementary specifications. Samples shall be obtained from linings made with the same type of machine and equipment and made from materials

similar to those which are to be used for cement-mortar lining under these specifications. Samples shall be large enough in area and shall be in sufficient number to indicate the surface finish, strength, solubility, and water absorption. Samples may be used by the purchaser in considering the acceptability of any bid. Samples of cement-mortar lining submitted by the successful bidder will be used by the engineer as a standard of comparison in determining the acceptability of the finished surface of cement-mortar linings.

Sec. 8—Inspection

8.1. The entire procedure of applying cement-mortar lining as herein specified shall be rigidly inspected, but inspection shall not relieve the contractor of his responsibility to furnish material and perform work in accordance with these specifications. If at any time it is found that the procedure of applying cement-mortar lining is not in accordance with these specifications, all lining so applied will be subject to rejection.

8.2. The inspector shall have free access to those parts of all plants that are concerned with the furnishing of material or the performance of work under these specifications.

8.3. The contractor shall furnish the inspector reasonable assistance, without charge, for inspection and for obtaining such information as he desires respecting the character of material used and the progress and manner of the work.

Sec. 9—Materials

9.1. *Portland cement.* Portland cement shall conform to Type II of ASTM C150 (Standard Specifications for Portland Cement), as last revised, or shall be as otherwise specified by the purchaser.

9.2. *Natural cement.* Natural cement shall conform to ASTM C10 (Standard Specifications for Natural Cement), as last revised.

9.3. *Pozzolanic material.* Pozzolanic material shall consist of siliceous or siliceous and aluminous material which, in finely divided form and in the presence of moisture, will react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties. Pozzolanic material shall meet the following detailed requirements, when tested in accordance with designated paragraphs of Federal Specifications SS-C-158c:

9.3.1. *Ignition loss.* Loss on ignition shall not exceed 10 per cent when tested in accordance with Paragraph 4.3.8.

9.3.2. *Fineness.* Material retained on a 325-mesh sieve shall not exceed 12 per cent, when tested in accordance with Paragraph 4.4.2.1.5.1.

9.3.3. *Compressive strength.* When 35 per cent by absolute volume of Type II Portland cement is replaced by the pozzolanic material, the 28-day compressive strength of mortar specimens fabricated with this mixture shall be at least 85 per cent of the 28-day compressive strength of specimens prepared with the straight Portland cement. Specimens shall be fabricated in accordance with Paragraph 4.4.8, with the following modifications: mix parts by weight shall be 1 part Portland cement (or mixture of pozzolanic and Portland cement), 2.75 parts of graded Ottawa sand, and sufficient water to obtain a flow of 100–115 using the method described in Paragraph 4.4.8.5. After being removed from the molds at 24 hr, the specimens shall be placed in airtight containers and stored

at 100°F for 27 days and then allowed to cool for 24 hr at 73°F ± 1.7°F before testing for strength. The average of three specimens for each mix shall be used in computation.

9.3.4. *Water requirement.* The amount of water required for cement-pozzolanic mortar to obtain a flow of 100–115, as described in Sec. 9.3.3 above, shall not exceed 115 per cent of the water required to obtain the same flow when using straight Portland cement.

9.4. *Sand.* Sand shall meet the following specifications:

9.4.1. Sand shall consist of inert granular material having hard, strong, durable, uncoated grains produced from hard crystalline rock. Sand shall be free from injurious amounts of dust, clay lumps, shale, soft or flaky particles, mica, loam, oil, and alkali. The maximum percentages by weight of deleterious substances shall not exceed the following limits:

Substance	Per Cent by Weight
Shale	1
Clay lumps	1
Mica and other deleterious substances	2
Sum of all deleterious substances	3

9.4.2. Sand shall not show a color value darker than the "reference standard color solution" prepared as required in ASTM C40 (Standard Method of Test for Organic Impurities in Sands for Concrete), as last revised. Sand shall be well graded and shall pass a 16-mesh screen.

Sec. 10—Preparation of Pipe Surfaces

The interior surfaces of pipe to be lined shall be cleaned by hand or machine, or both, and loose scale, tuberculation, loose deteriorated remains of old coating materials, and all accumulations of dirt and debris shall be removed. There shall be no sharp edges between coated and uncoated areas. Shot or sand blasting is not required to prepare surfaces of pipe for lining. Oil and grease shall be removed from interior surfaces. Accumulations of water on the bottom of the interior of the pipe shall be removed.

Sec. 11—Openings

Prior to placing the lining, openings in the pipeline leading to air valves, blowoffs, manholes, and other appurtenances, as well as the ends of pipes which transmit pressure or carry water from the pipeline, shall be temporarily covered or plugged with wooden stoppers, which shall be removed later without damaging the cement-mortar; or other suitable arrangements shall be provided. All access openings required for the lining work shall be made and closed by the contractor in the manner required by the purchaser.

Sec. 12—Mortar for Lining

12.1. Mortar for the lining shall be composed of cement, sand, and water, well mixed and of proper consistency to obtain a dense, homogeneous lining that will adhere firmly to the pipe surface.

12.2. The proportions of cement and sand in the mortar for the lining shall be 1 part of Portland cement to 1–1½ parts of sand by volume, the exact proportions to be determined by the characteristics of the sand used. Natural cement or pozzolanic material, unless otherwise specified by the purchaser, may be substituted for a part of the Portland cement in a proportion of no more than 1 part of natural cement or pozzolanic material to 5 parts of Portland cement by volume.

12.3. The water content shall be kept to a minimum, with allowance being made as necessary for moisture collecting on interior pipe surfaces.

12.4. Where premixed mortar is used in the lining machine, premixing shall be for a sufficient length of time, approximately 3 min, to obtain maximum plasticity, and premixed mortar shall be used before initial set has taken place.

Sec. 13—Thickness of Cement-Mortar Lining

13.1. Cement-mortar lining shall be uniform in thickness except at joints or deformation in pipelines. Cement-mortar lining thickness shall be as specified by the purchaser, and the tolerance for thickness is plus $\frac{1}{8}$ in.; no minus tolerance for thickness is allowed.

13.2. The thickness of cement-mortar lining over the top of rivet heads and lock-bar longitudinal seams of steel pipe shall be not less than $\frac{1}{8}$ in., unless otherwise specified by the purchaser.

Sec. 14—Application and Surface Finish

14.1. Immediately prior to the travel of the lining machine through the pipeline, all foreign material, including sand and loose mortar, that has accumulated since the work of preparation of surfaces was completed shall be removed.

14.2. The lining shall be applied in one course by a machine projecting the mortar against the surface of all pipe sections and long-radius bends, without injurious rebound and with sufficient velocity to cause the mortar to be densely packed and to adhere in place. The rate of travel of the machine and the rate of discharge of mortar against the wall of the pipe shall be entirely mechanically controlled so as to produce a smooth, uniform thickness of lining throughout the interior of the pipeline. The machine shall be provided with attachments for mechanically troweling the mortar, and the machine shall travel ahead of the lining so that the freshly placed and troweled mortar will not be touched until it has set. The trowel arrangement shall be such that the pressure applied to the lining will be uniform, will produce a smooth surface without spiral shoulders, and will produce a lining of uniform thickness.

14.3. Hand application of mortar at the line of rivet heads in steel pipe may be used to streamline the projection of the mortar over such rivet heads. Open joints shall be packed with mortar prior to lining, to provide a smooth surface across the joint. Such mortared areas shall be moist and unchecked prior to machine lining.

14.4. The finished surface shall be smooth and shall not have a sand finish. The finished surface of machine-placed and -troweled linings shall be tested for finish, and nine out of ten places checked shall conform to the tolerance for finished surfaces. The finished surface shall be such that if a 12-in. straightedge is laid parallel to the axis of the pipe along the surface of a straight section of machine-placed and -troweled lining, at no point will the space between the lined surface and the straightedge be greater than $\frac{1}{32}$ in. for smooth-bore pipe in good condition and $\frac{1}{16}$ in. for pipe having a rough or irregular interior. Such tolerance for surface finish, however, shall not apply where the interior surface of the pipe to be lined does not meet the foregoing conditions.

14.5. Samples of cement-mortar lining furnished by the contractor will be used by the engineer as a standard of

comparison in determining the acceptability of the finished surface of cement-mortar linings, if the purchaser requires such samples to be furnished in his supplementary specifications, in accordance with the provisions of Sec. 7 of these specifications.

14.6. Defective lining material—including, but not restricted to, sand pockets, voids, oversanded areas, blisters, drummy areas, excessively cracked areas, and unsatisfactory thin spots—shall be removed to the pipe wall, and the area shall be repaired by hand application to the full required thickness of the mortar lining.

Sec. 15—Hand Mortar Work

15.1. Cement-mortar lining of sharp bends, specials, and areas closely adjacent to valves where machine placing is impossible, together with the correcting of defective areas, shall be done by handwork. Hand-placed mortar shall have a surface which has a uniform appearance, with smooth transitions to the adjacent machine-placed lining.

15.2. Cement-mortar for handwork shall be of the same materials as the mortar for machine lining.

15.3. Areas shall be thoroughly cleaned of all loose and foreign material, and, if necessary, shall be moistened with water just prior to the placing of the mortar being applied by hand.

15.4. Steel finishing trowels shall be used for the hand application of cement-mortar, except at bends. The outer edges of hand-troweled areas may be brushed to reduce the abutting offset.

15.5. All hand finishing work in a section of the pipeline shall be completed within 24 hr after the machine application of mortar lining to that particular section of the pipeline has been completed. Machine application of mortar lining shall be slowed down or stopped, if necessary, to assure hand patching of defective machine-lined areas in accordance with this schedule.

Sec. 16—Curing

16.1. Curing operations shall begin immediately after completion of the mortar lining and hand finishing of a section of the pipeline. The pipe shall be closed, and a moist atmosphere shall be maintained in this section of the pipeline to keep the lining damp and to prevent evaporation of water from the mortar lining.

16.2. Sections of the mortar-lined pipe will be filled with water by the purchaser, unless otherwise provided, as soon as possible after lining operations, but no pressure, except that induced by variations in the grade of the pipeline, will be put on any section until the mortar lining has been in place not less than 24 hr. The contractor shall be responsible for careful curing of the mortar lining of completed sections of the pipeline until such sections are filled with water by the purchaser, or until the lining work has been accepted by the purchaser.

16.3. The exterior surfaces of pipe exposed to sunlight shall be sprinkled with water in the daytime during the lining, finishing, and curing period.

Sec. 17—Guarantee

In the event that examination of the cement-mortar lining work, made by the purchaser within a period of 1 year after final completion and acceptance of the contract work, reveals evidence of defective materials or workmanship, the purchaser may order such defective lining replaced, and the contractor shall remove and replace it at his own expense in a manner acceptable to the purchaser.

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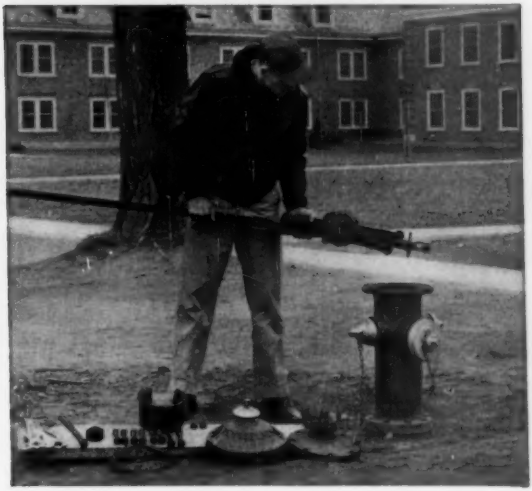

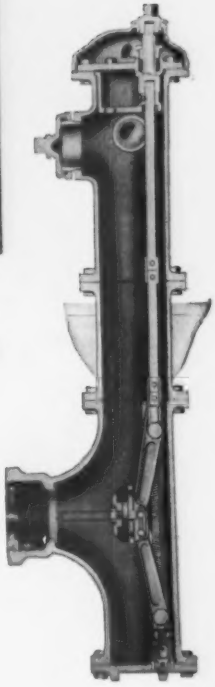

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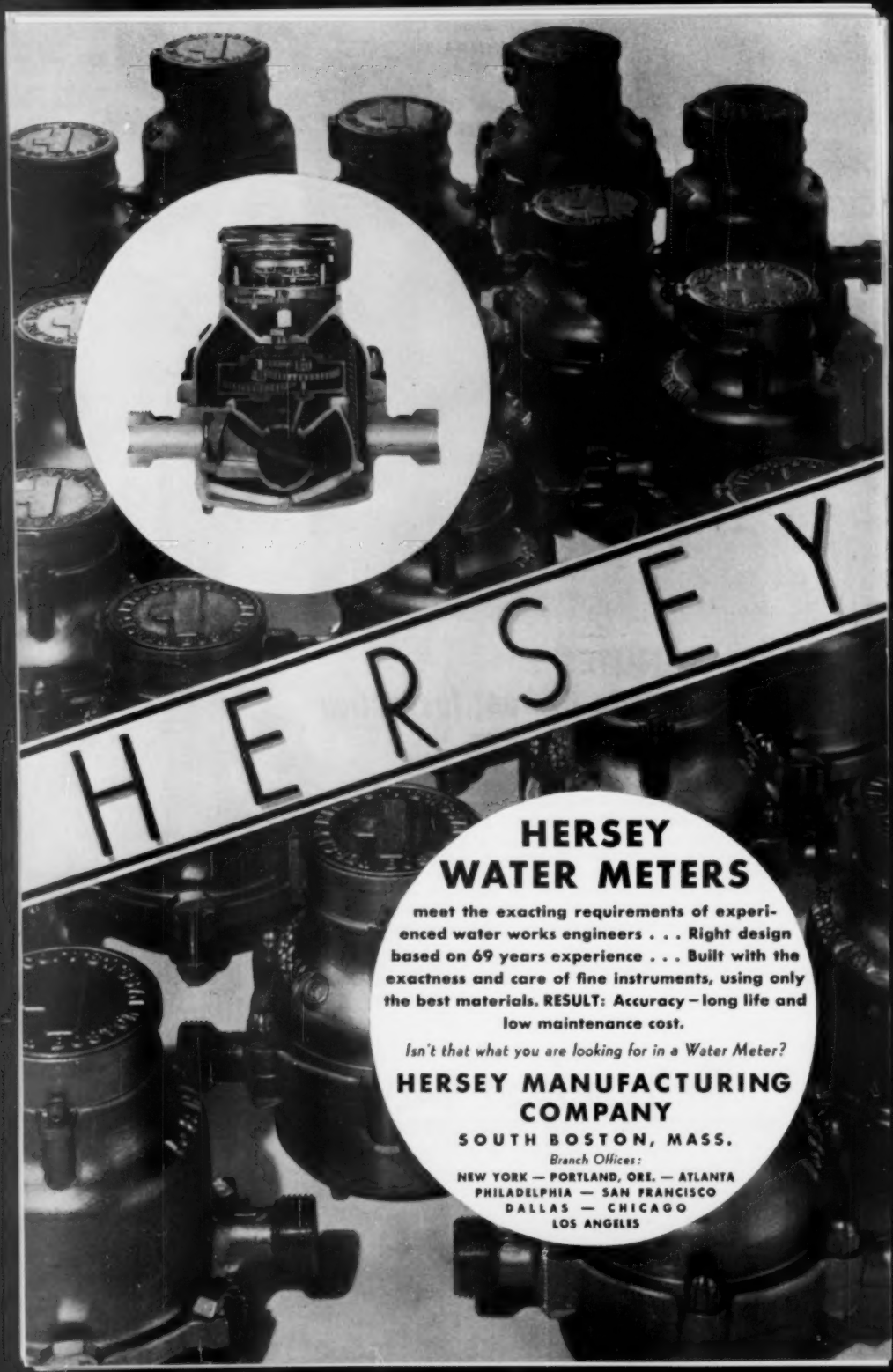
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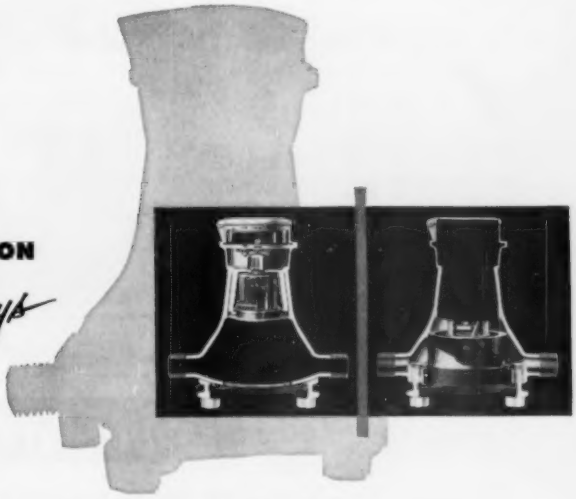

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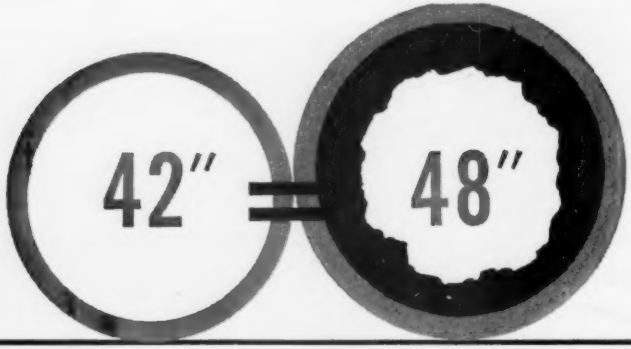

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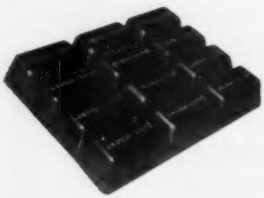

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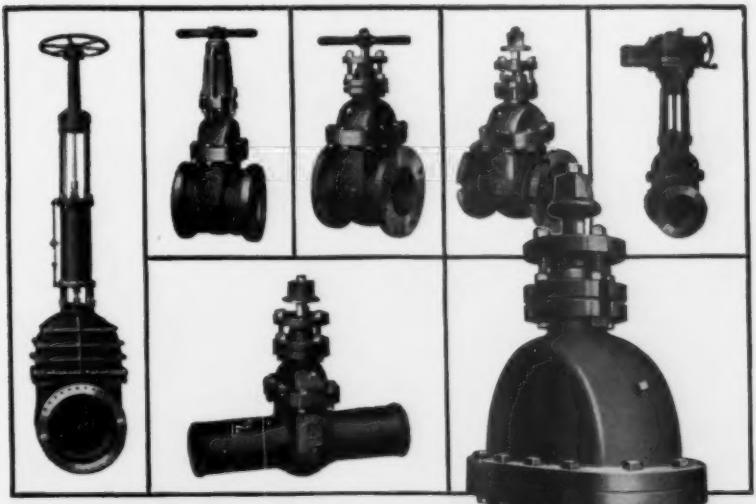

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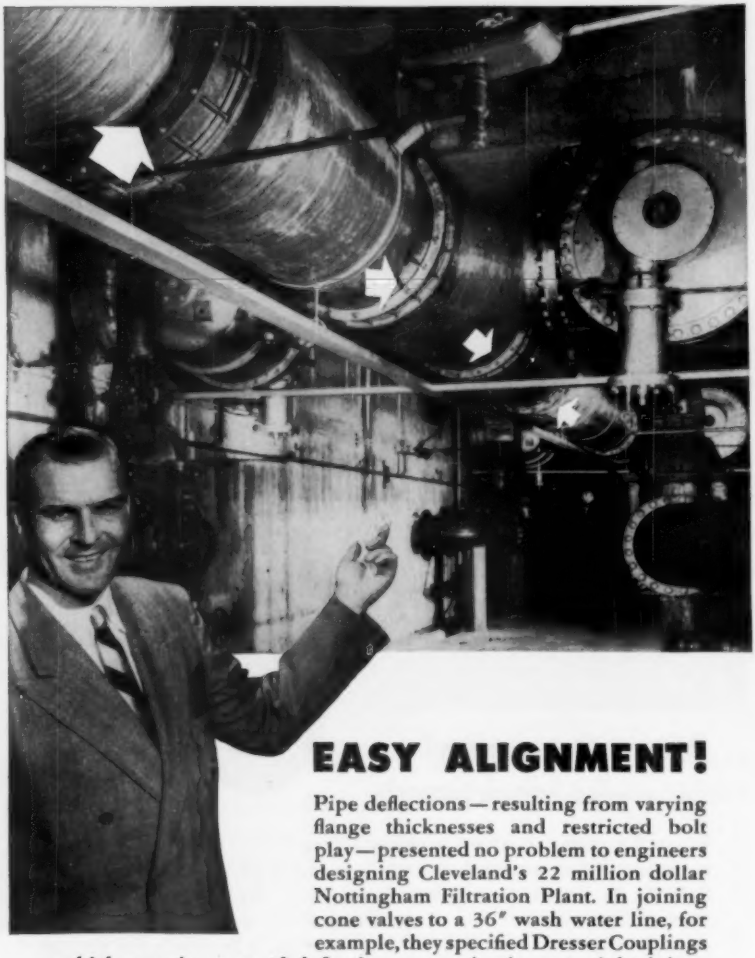

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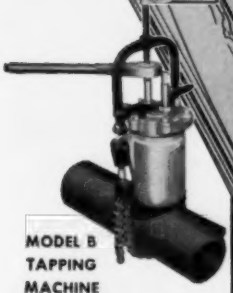

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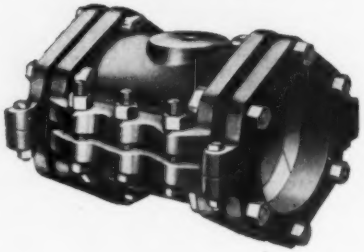

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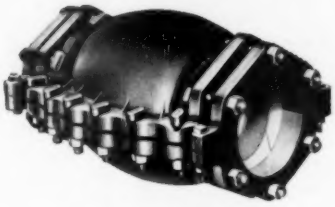

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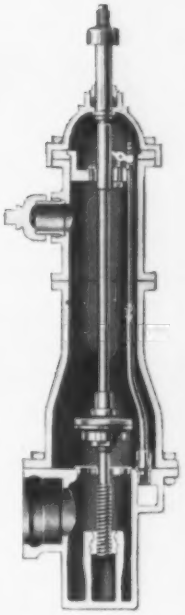

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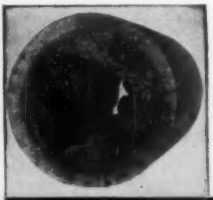

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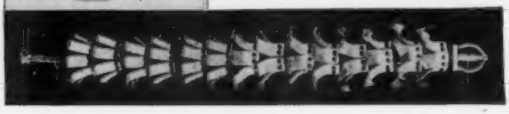

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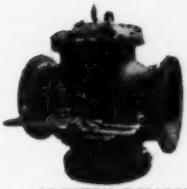

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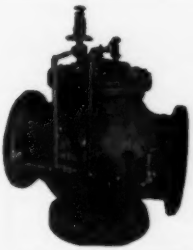

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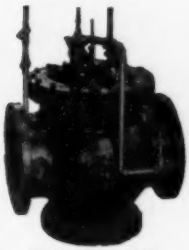

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1. As direct acting

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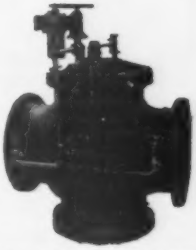

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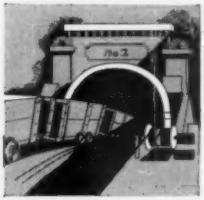

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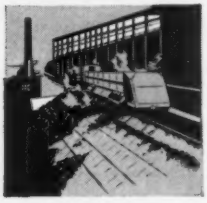

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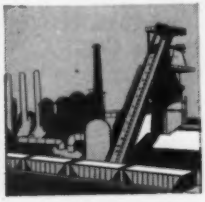

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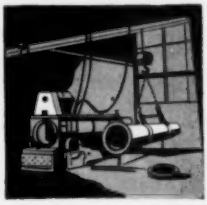

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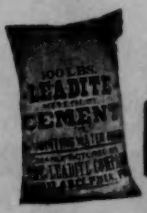

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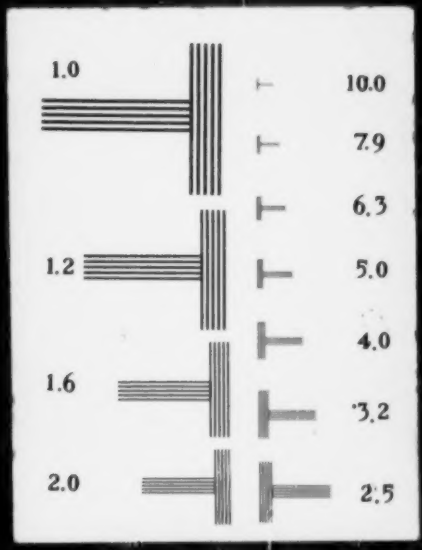

100 MILLIMETERS

INSTRUCTIONS Resolution is expressed in terms of the lines per millimeter recorded by a particular film under specified conditions. Numerals in chart indicate the number of lines per millimeter in adjacent "T-shaped" groupings.

In microfilming, it is necessary to determine the reduction ratio and multiply the number of lines in the chart by this value to find the number of lines recorded by the film. As an aid in determining the reduction ratio, the line above is 100 millimeters in length. Measuring this line in the film image and dividing the length into 100 gives the reduction ratio. Example: the line is 20 mm. long in the film image, and $100/20 = 5$.

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